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A Magazine of Methods for Operating Men

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The Course of Oil

By K. C. SCLATER

Coöperative Training Program

In the Spring of this year the Kilgore College at Kilgore, Texas, in the heart of the East Texas oil field, made a survey to determine what could be done "to render a broader, more effective educational service to the youth of this area and to the industry in which great numbers of them must eventually seek a livelihood."

It was revealed that "hundreds of young people graduating from high schools in this area are too young and too inexperienced to obtain employment upon graduation. At the same time, a majority of these young people are unable to continue their formal education under existing circumstances."

A plan has been adopted and worked out that "it is believed will help bridge the gap between high school graduation and employment. The plan provides for a college course to be known as Part-Time Co-Operative Training for the Petroleum Industry. The College and the industry coöperate in giving high school graduates part-time college training and part-time work experience."

It was only after some two hundred employers in the East Texas field had been interviewed that the plan was adopted and worked out by the Board of Trustees of Kilgore College, "in coöperation with the Trade and Industry Division of the State Board for Vocational Education."

The tentative plans outlined for the training courses indicate the scope of the project.

"The student in this course will receive college training in the morning. About half his college time will be devoted to the study of material bearing directly on his afternoon employment. He will work a minimum of twenty hours per week in the afternoons in some occupation in the petroleum and related industries.

"Students in the course will be high school graduates with genuine interest in the petroleum industry. They will be between the ages of eighteen and twenty-five. They will apply for admission, using a special application blank. This application, the student's high school record and photograph will be available to coöperating employers to aid them in selecting the applicants whom they wish to interview.

"The college has employed two men to work with these students. One, the teacher of the related subjects, will supervise the study of the material directly related to the students' employment. The other, the coördinator, will work with the employers in planning the college work to supplement the students' work experience. Both of these men are experienced petroleum industry employees.

"The college is assembling a special reference library for the use of these students. When the fall (1940) session opens there will be in this library thousands of items, including text books, hand books, all the leading magazines, American Petroleum Institute publications, Bureau of Mines bulletins, manufacturers' catalogues and bulletins, etc.

"The college will undertake systematic safety training and, with the coöperation of the Bureau of Mines, give the regular first-aid course. The National Safety Council is coöperating in this work also.

"The coördinator will regularly confer with the employer to offer his assistance in any problems which may arise during the course of training.

"The coöperating employer will offer employment at a nominal rate of pay to be recommended by the Advisory Committee for a minimum of twenty hours per week (equivalent to laboratory work) during the two-year training period. He will select the student he desires to employ and will offer him work experience opportunities in accord with his routine operations.

"An advisory committee will be formed of representatives of the various branches of the petroleum industry. This committee will meet at regular intervals and will advise the college administration on all matters pertaining to instruction, rates of pay, training opportunities, etc.

"Craft committees will be formed with the advice of the advisory committee, each committee to be composed of a number of men from each occupation for which one or more students are training. The craft committee will meet frequently with the college staff to plan the details of the course of study for each division of the industry. For example, the Craft Committee on Production will be composed of outstanding production men who will meet with the coördinator and related subjects teacher of the college to work out the course of study best suited for the purpose of training the students employed in production work. The same plan would be followed for each of the other occupations.

"On the basis of the survey and the interviews with 200 employers the following occupations are such that the beginner needs two years of part-time work and training to equip him to enter into full-time employment in them:

Production of Petroleum.

Production of Natural Gas

Pipe Line Transportation of Petroleum and Natural Gas

Distribution of Natural Gas

Refining of Petroleum

Manufacture of Natural Gasoline

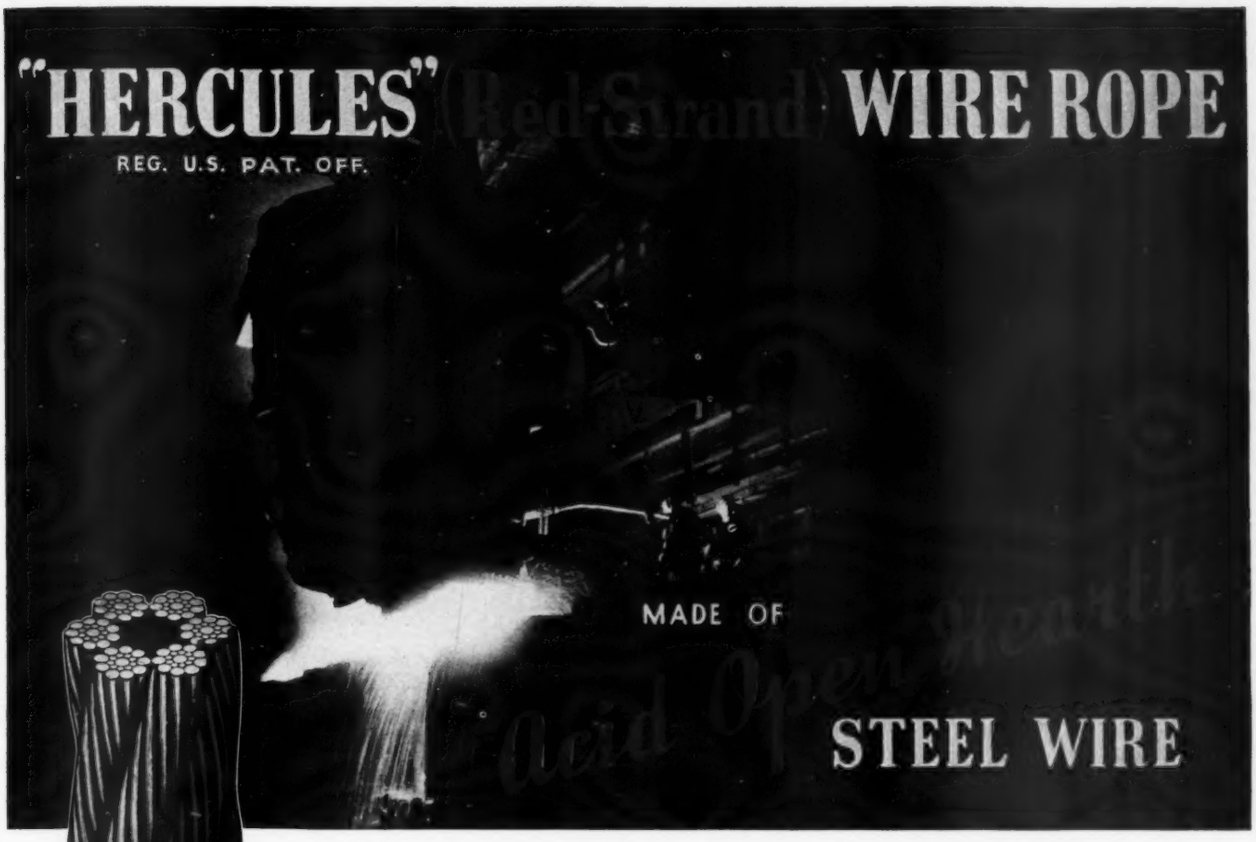
Distribution of Oil Field Equipment and Supplies

Repair and Maintenance of Oil Field Mechanical Equipment

Repair and Maintenance of Oil Field Electrical Equipment."

The support already given by employers to the project augurs well for its success.

Here is an educational undertaking that merits encouragement from the industry.



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« « HIGHLIGHTS IN OILDOM » »

Interstate Oil Compact Commission Meets

Robert E. Wilson, president of Pan American Petroleum and Transport Company, now petroleum technician on the staff of the National Defense Advisory Commission, and W. R. Boyd, Jr., executive vice-president of the American Petroleum Institute, expressed to the meeting of the Interstate Oil Compact Commission at Oklahoma City, Oklahoma, their opinion that the petroleum industry is unquestionably able to meet any emergency demand made upon it in connection with national defense. Wilson's opinions were transmitted by letter to the meeting, his duties in connection with the defense program preventing attendance. Boyd delivered his address in person.

Among business transacted by the commission was the adoption of a resolution recommending that coöperating oil-producing states reduce crude oil production 5 percent below estimates of market demand during the next four months as a means of preventing waste in time of national emergency.

Arthur Schoeppel, representative from Kansas, suggested extension of the commission's activity to include legal, engineering, and regulatory aspects of the body's physical-waste program. He suggested creation of a general committee composed of one member from each of the states represented on the compact commission to supervise three subcommittees consisting insofar as possible of representatives from the various state regulatory bodies.

●

Michigan Crude Oil Prices Advanced

Advances in crude oil prices in Illinois, Indiana, and Kentucky, announced recently, have been followed by increases in Michigan.

The Pure Transportation Company, Leonard Petroleum Company, and Bay Pipe Line Company increased the posting for central Michigan fields 10 cents a bbl. Pools affected and new prices are: Midland, $1.12; Temple, $1.07; Sherman, Freeman, and Reading, $1.07; Buckeye-Bentley, $1.10; Saginaw and Wise, $1.12; and Clare, heavy, 81 cents. The last was a 5-cent advance.

Simrall Corporation, a buying unit of the Standard Oil Company of Ohio, advanced prices 10 cents to $1.18 in the Allegan, Kent, and Ottawa pools.

Fields in Van Buren County were exempted from the earlier advances but later a posting of $1.12 a bbl. gave that area an increase of 4 cents.

●

Further Increases in Kentucky Crude Prices

Touched-off by advances in the Birk City and Corydon pools early in August, Kentucky crude oil price increases became greater and more general the latter part of the month.

Ashland Oil and Transportation Company increased its market schedule 10 cents per bbl. to the following: Kentucky River production, $1.20 per bbl., and Big Sandy River production, $1.12.

Paul J. Calvert, superintendent of the Owensboro Ashland Company, announced an increase to $1.10 per bbl. from $1.00 on western Kentucky crude oil and said similar increases had been made by his company in eastern Kentucky.

Carl Morris, general manager of the Producers Pipe Line Company, announced prices had been increased by his company to $1.10 per bbl. from $1.

The Sohio Corporation, through Frank Wilson, president, announced an increase to $1.05 per bbl. from 95 cents for Birk City and Henderson production.

Nine-Day Shutdown Ordered for Texas Wells

The Texas Railroad Commission placed into effect on September 1 a 90-day order that decreed 9 statewide shutdown days each month. Shutdown days were ordered for September 1, 2, 8, 14, 15, 21, 22, 29, and 30; October 5, 6, 12, 13, 19, 20, 26, 27, and 31, and November 2, 3, 9, 10, 16, 17, 24, 28, and 30.

The order set the average daily allowable production for Texas at 1,298,528 bbl.

●

Ask Rehearing in East Texas Oil Suit

Attorneys for the Rowan and Nichols Oil Company have petitioned the United States Supreme Court for a rehearing in the East Texas oil proration case. A brief has been filed urging the court to reconsider its decision of June 3, in which it upheld proration of the field on a basis of 2.32 percent of hourly potential.

One of the principal contentions advanced is that the court erroneously understood the marginal well allowance in relation to the total field allowable.

"The opinion clearly shows that the court is confused on the facts of the case and contentions of the respondents (Rowan and Nichols)," it was stated in supporting argument for the rehearing motion. "Confusion on the facts has caused the court to ground its decision upon rules of law which are not applicable to the facts of this case." The opinion proceeds, the petition contends, "upon the erroneous theory that the proration regulation involved in the suit prorated the daily field allowable among wells on a potential basis, except that production allocated to marginal wells absorbed so much of the daily field allowable that distribution of the field allowable was substantially on a per-well basis, and that the issue in the case is the reasonableness of a potential method of proration as compared with a method of proration based on acre-feet of sand; when, in point of fact, there were only approximately 451 marginal wells in the field with a total daily production of only approximately 5250 bbl. of oil, and the method of proration was not materially affected by the allowance to marginal wells, and the allowance to them did not cause what otherwise would have been a potential method of proration to become a per-well method of proration."

Exception was taken to the court's statement that operation of the order was "largely cut across by allowances made to marginal wells," and that "because of the large number of the low-capacity units in the East Texas field, approximately 385,000 bbl. out of a total daily allowable of 522,000 bbl. were exempt from the restricting formulas, leaving only about 136,000 bbl. for the class within which the respondent's wells fell."

It was asserted by attorneys for Rowan and Nichols that there were only 451 marginal wells having a total allowable of 5250 bbl., or only about 1 percent of the field total.

The complaint of Rowan and Nichols, the petition continued, "was that the commission abandoned the terms of its order providing for proration on a well potential basis and was, in fact, enforcing proration upon substantially a per-well basis." That contention was predicated upon the allegation that the commission allowed each non-marginal well, or those capable of producing more than 20 bbl. per day, a minimum allowable of 20 bbl. per day "without regard to whether its potential was 20 bbl. or 20,000 bbl. a day."

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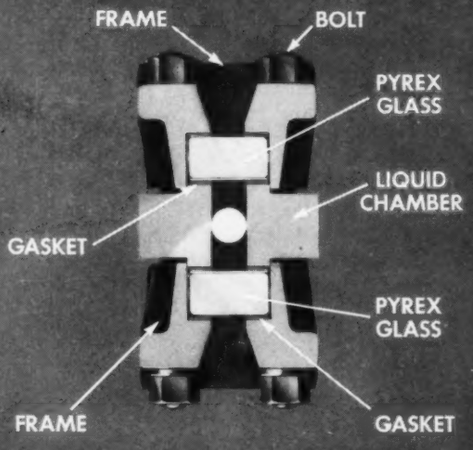

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DETROIT, MICHIGAN

PENBERTHY PRODUCTS

CANADIAN PLANT:
WINDSOR, ONTARIO

Activities in Refining

Percent Refining Capacity Operated

Western Division, 70.0 Percent **Central Division, 75.7 Percent** **Eastern Division, 92.2 Percent**

LONE STAR GAS COMPANY and the Shamrock Oil and Gas Company have announced plans for the erection of a recycling plant on their holdings on the Opelika structure of eastern Henderson County, Texas, to manufacture natural gasoline and return the residue gas to the producing formation for repressuring.

The plant will have a capacity of about 30,000,000 cu. ft. of gas per day. Initially the plant will have two compressor units, which number likely will be increased later as gas production on the structure is increased.

It is expected that the plant will be completed about March 1.

Producing wells in the area, which are at a depth of about 8000 ft., have a shut-in pressure of 3000 lb. per sq. in.

●

Orders for two gas-driven turbines, the first to be built for sale by the company, have been received by the General Electric Company. One unit will be used by a California oil refinery, and the other by a Texas refinery.

Details of the machines cannot be revealed as the catalytic processes in which they will be involved are secret. Fundamentally, however, they will be similar to usual steam turbines except that they will operate on high-temperature by-product gases that otherwise would be wasted. The units will be rated 3250 hp. and 400 hp.

●

Standard Oil Company of Ohio is installing a catalytic polymerization unit and additional storage tanks at its main refinery at Cleveland, Ohio, as a part of a program that calls for the expenditure of more than $1,000,000 for equipment of this type at the company's refineries in Cleveland, Lima, and Latonia.

●

Plans for the first gasoline and recycling plant for the Rogers pool, west of Nocona, Texas, have been announced by Lesh and McCall, Nocona operators.

The plant will have a capacity of 15,000,000 cu. ft. of gas per day. A part of the residue gas, about 1,000,000 cu. ft., will be sold to the City Gas Company to supply the town of Nocona and the rest will be returned to the producing sand for pressure maintenance.

The Continental Oil Company is considering the erection of a recycling plant in the Hull-Silk pool, Archer County, Texas. A meeting of operators in the area was held in Wichita Falls recently at which time Ed McFarlin, John F. O'Donohoe, and John W. Thomas were named as a committee to work with Continental officials.

E. O. Bennett, Ponca City, Oklahoma, chief petroleum engineer for Continental, and M. H. Shanahan, assistant manager of production and pipe lines in Texas, suggested the company might build the plant under a plan whereby operators would be charged on a prorata basis until Continental's investment was returned after which the price of input gas would be reduced to cost.

●

Standard Oil Company of New Jersey has announced a $3,000,000 appropriation for refinery modernization and terminal expansion. Of this sum $2,500,000 will be spent at the Bayway refinery. At Linden, New Jersey, $478,000 will be expended to construct a 30-ft. by 575-ft. pier and tanker dock.

●

The Republic Oil Refining Company has put into operation at its Texas City, Texas, refinery a new Gray clay treating installation. This installation will be used to refine the cracked gasoline produced by a recently completed cracking plant.

●

Danciger Oil and Refineries, Inc., of Tulsa, Oklahoma, is converting the cracking unit in its refinery at Pampa, Texas, to operate the Dubbs cracking and reforming processes. As revamped, the cracking unit will be of the 2-coil selective type, residuum flashing, with stabilizer and absorber equipment. A catalytic polymerization unit is also being installed.

The rated capacity of the cracking unit will be 3000 bbl. per day of topped crude; reforming capacity 900 bbl. per day. The poly unit is expected to process about 620,000 cu. ft. of cracked gas per day to produce polymer gasoline.

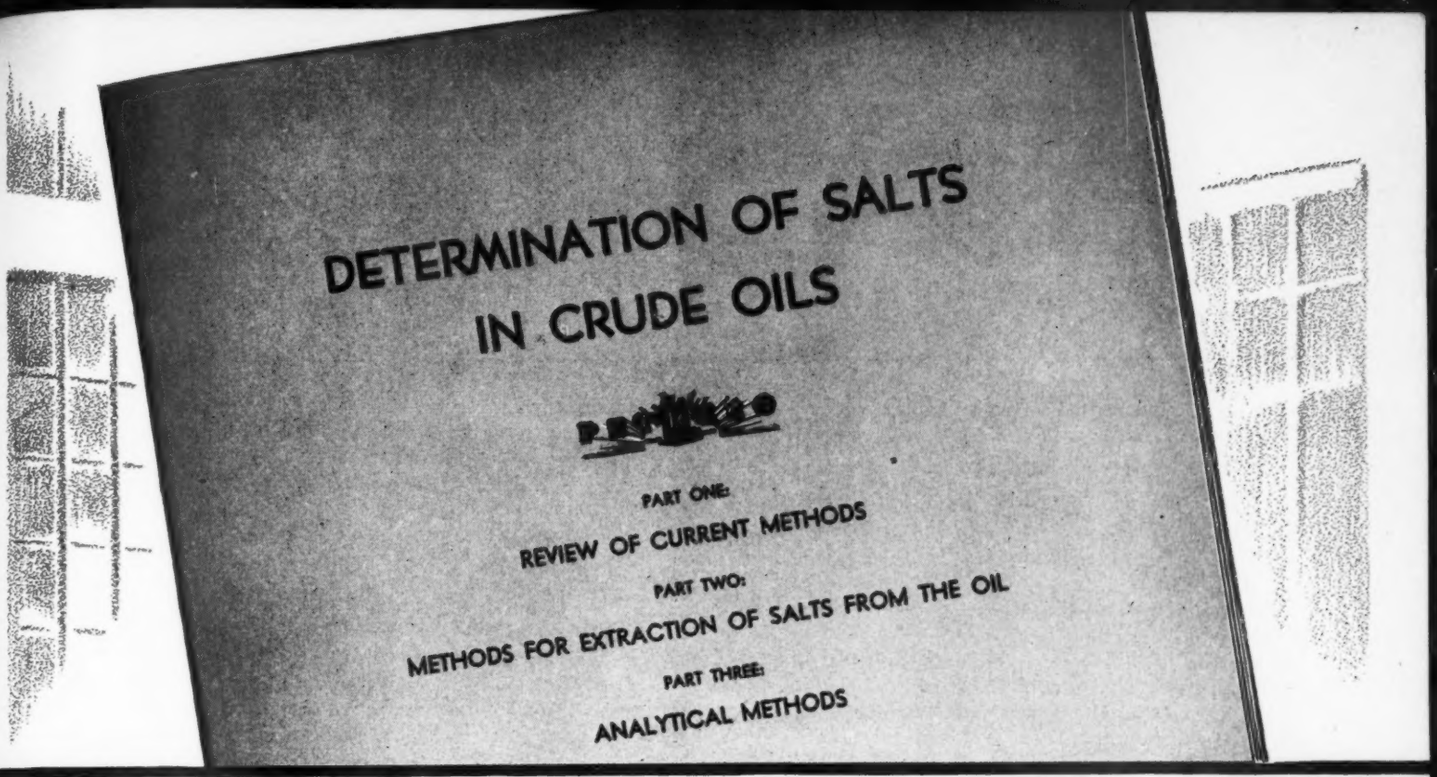
At present the Pampa refinery is running 6000 bbl. of Gray County, Texas, crude oil per day.

Dan Danciger is president of the company; Joe Danciger, vice-president and treasurer; Jack Danciger, vice-president and assistant secretary, and A. Danciger, vice-president. Fred Shyrock is refinery superintendent.

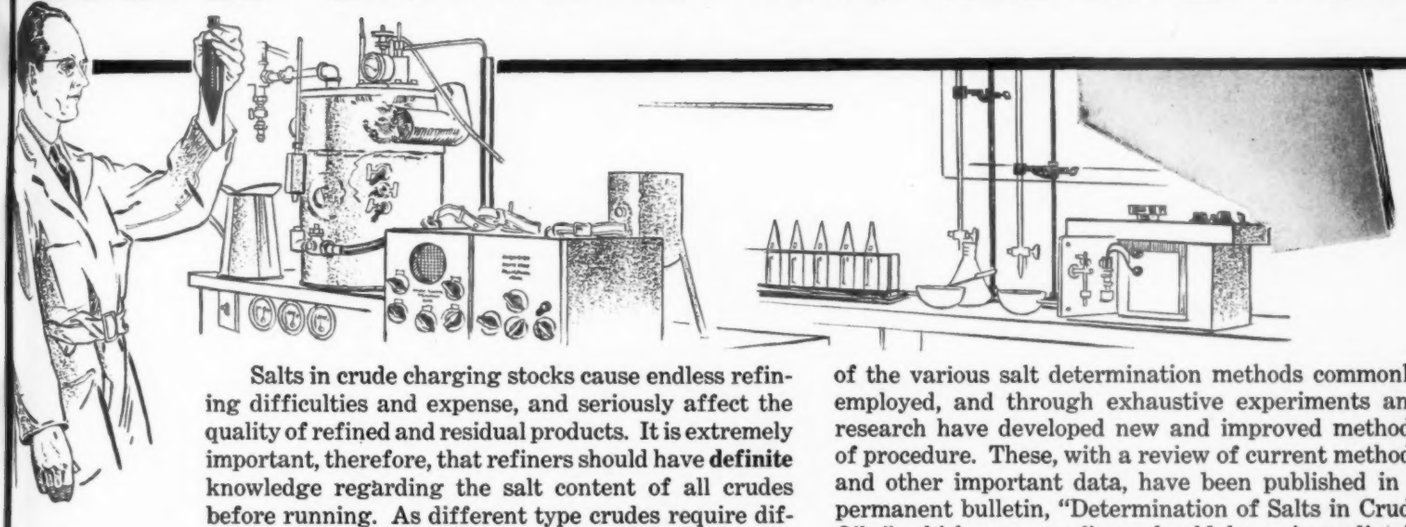
Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended August 31, 1940
A.P.I. Figures
(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	600	93.3	21,776	28,711
Appalachian	91.0	131	92.3	3,320	988
Ind., Ill., Ky.	90.2	610	91.0	14,694	8,841
Okla., Kans., Mo.	76.9	275	85.1	6,278	3,818
Inland Texas	59.6	102	61.1	1,630	1,884
Texas Gulf	85.3	743	81.3	11,227	14,476
La. Gulf	97.6	112	70.0	2,502	2,668
No. La. and Ark.	51.5	42	80.8	428	775
Rocky Mt.	56.0	40	58.8	895	637
California	87.3	548	75.1	15,643	86,942
Reported	85.3	3,203	82.8	78,393	149,720
Estimated Unreported	.....	372	.....	7,000	3,820
*EST'D TOTAL U.S. AUG. 31, 1940	.....	3,575	.....	85,393	153,540
*EST'D TOTAL U.S. AUG. 24, 1940	.....	3,485	.....	85,770	151,952
U. S. B. of M. *AUG. 31, 1939	.....	**3,472	.....	72,335	153,240

*Estimated U. S. Bureau of Mines basis.
**August, 1939, daily average.



EVERY REFINERY SHOULD HAVE *this IMPORTANT INFORMATION*



Salts in crude charging stocks cause endless refining difficulties and expense, and seriously affect the quality of refined and residual products. It is extremely important, therefore, that refiners should have **definite** knowledge regarding the salt content of all crudes before running. As different type crudes require different techniques for determining salt content, it is equally important that dependable methods of salt determination be utilized.

Petreco technicians have made an intensive study of the various salt determination methods commonly employed, and through exhaustive experiments and research have developed new and improved methods of procedure. These, with a review of current methods and other important data, have been published in a permanent bulletin, "Determination of Salts in Crude Oils," which every refiner should have immediately available. It will prove invaluable in combatting salt troubles such as corrosion, plugging, scaling, coke formation, and products of inferior quality. Copies will be supplied to any refinery executive gratis, on request.

Eliminate The Trouble By Removing The Cause

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Eastern Division:
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Representatives in Principal Oil Fields and Refining Centers

PETRECO

DE-SALTING DEHYDRATING

Activities in the Oil Fields

UNION Producing Company's Powell No. 1 in CSE SW of 36-11-3w, Tinsley pool, Yazoo County, Mississippi, has opened first oil production in the area from the Tuscaloosa formation. The well was drilled to a total depth of 6223 ft. and casing was perforated from 6110 ft. to 6115 ft., the test flowing 632 bbl. in 26 hours through choke.

●

Ramsey Petroleum Corporation's Viersen No. 1, SW SE SE of 5-5-10, Hughes County, Oklahoma, recovered an oil-stained core from the upper Cromwell sand between 4476-94 ft. and later on a drill-stem test produced 630 ft. of oil and 1350 ft. of salt water in 30 minutes. The operator was drilling ahead with the second Cromwell as the goal. Observers said the well was good for a small producer in the upper Cromwell if plugged-back.

●

Opening of a new pool in northwestern Lea County, New Mexico, is indicated by State No. 1-D of Great Western Products, Inc., in section 30-12s-32e, less than a mile east of the Chaves County line. The test filled 2100 ft. with fluid the first 24 hours after drilling red sand from 3025 ft. to 3035 ft. Of this fluid 1600 ft. was oil and 500 ft. salt water. The sand zone is said to correspond to the Artesia or Maljamar sand found productive farther southwest.

●

A good showing of oil has been obtained from the Silurian formation in the Illinois Basin, a zone that heretofore has not been productive in the area. The discovery was made in a former Devonian producer that was deepened by Allan Borton on the Storer lease west of the city limits of Centralia. The showing was obtained on a drill-stem test at a depth of 3700 ft.

Four miles southeast of the Halsell pool, Clay County, Texas, W. I. Howard No. 1, a wildcat test of H. M. Horton and P. N. Wiggins, Jr., has opened a new Caddo lime producing area. After acid treatment with 2500 gal., the well produced an estimated 25 bbl. of oil per hour through 5½-in. casing, and through tubing the flow was estimated at 10 to 12 bbl. per hour. The hole was drilled to a total depth of 5600 ft. and plugged-back to 5488 ft.

●

Humble Oil and Refining Company's Leger No. 1, in the South Crowley area of Acadia Parish, has given Coastal Louisiana a new field. The well was completed at a depth of 7612 ft., producing 35 bbl. of 36-gravity oil per hour through ¼-in. choke.

●

R. E. Havenstrite, independent operator, has discovered the first new oil field in California since August, 1939, with the completion of Lincoln No. 1, in the Newhall district of Los Angeles County, 3½ miles west of Castaic. On the initial test the well flowed at the rate of 1350 bbl. per day through a 16/64-in. bean. The oil tests 48 gravity. Gas is estimated at 10,000,000 cu. ft. per day. The well was drilled to a total depth of 6948 ft. An 8⅝-in. water string was cemented at a depth of 6653 ft.

●

R. R. Bush Oil Company has completed its Inglewood, California, deep test, Sentous No. 1, which flowed by heads at an estimated rate of 500 bbl. per day of 31.8-gravity oil. It is necessary to run the swab occasionally to maintain flow. A perforated liner was landed on bottom at a depth of 8760 ft. Casing was cemented at 8325 ft. The well is located on the west flank of the old Inglewood field.

AVERAGE CRUDE OIL PRICES

California	
Kettleman Hills	$1.12-1.38
Playa Del Rey	.65-1.08
Coalinga	.60- .82
Wilmington	.64-1.14
Montana	.80-1.10
Wyoming	.35-1.30
Colorado	.90- .98
New Mexico	.77-1.00
Texas	
North Central	.71-1.03
Panhandle	.67- .96
West Texas	.53- .95
Gulf Coast	.86-1.28
Darst Creek	.96
East Texas	1.10
Talco	.65
Kansas	.60-1.10
Oklahoma	.60-1.10
Arkansas	.73-1.05
Louisiana	
Rodessa	$1.05
Gulf Coast	.79-1.28
North Louisiana	.73-1.05
Illinois	1.15
Kentucky	1.05-1.20
Indiana	1.00
Ohio	
Lima	.90
Michigan	.81-1.18
Pennsylvania	
Bradford	1.85
Southwest	1.50
Eureka	1.44
Buckeye	1.55
Corning	1.12
Canada	2.10-2.17

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

	[1]B. of M. Calculated Requirements (September)	Week Ended Sept. 7, 1940	Week Ended Aug. 3, 1940	Week Ended *Sept. 9, 1939
Oklahoma	397,000	[2]421,700	410,000	242,000
Kansas	170,700	[2]165,750	183,150	93,150
Nebraska	.....	[2] 200	150	.....
Panhandle Texas	.....	76,500	66,000	43,400
North Texas	.....	96,200	84,750	84,800
West Central Texas	.....	29,650	28,250	32,950
West Texas	.....	221,500	182,600	254,200
East Central Texas	.....	78,650	72,950	87,400
East Texas	.....	374,900	374,850	383,900
Southwest Texas	.....	211,200	174,700	230,950
Coastal Texas	.....	210,600	185,800	232,650
TOTAL TEXAS	1,320,300	1,299,200	1,169,900	1,350,250
North Louisiana	.....	64,800	63,150	61,450
Coastal Louisiana	.....	213,250	216,950	163,600
TOTAL LA.	274,700	278,050	280,100	225,050
Arkansas	69,700	73,250	72,400	52,500
Mississippi	9,700	[2] 28,650	11,750	.....
Illinois	430,000	380,000	406,650	321,500
Indiana	9,300	[2] 18,300	14,750	92,700
Eastern (Not incl. Ill. and Ind.)	91,900	90,350	91,700	
Michigan	55,700	52,250	54,750	66,500
Wyoming	75,300	71,100	69,300	60,200
Montana	17,700	17,750	18,750	16,450
Colorado	4,000	3,600	3,550	3,600
New Mexico	105,300	100,700	105,050	82,950
TOTAL EAST OF CALIF.	3,031,300	3,000,850	2,891,950	2,606,850
California	593,000	623,000	601,600	621,800
TOTAL U. S.	3,624,300	3,623,850	3,493,550	3,228,650

[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of September. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

[2]Oklahoma, Kansas, Nebraska, Mississippi, and Indiana figures are for week ended 7 A. M. September 4.

*Production partially shut down as a result of state order.

Great Pioneers

KENTUCKY 1853

An impressive list of "firsts" characterizes Kentucky as the "Pioneer Commonwealth." It was the first region settled in the westward movement—Harrodsburg was the site of the first permanent English settlements. Kentucky had the first state Constitution to provide full manhood suffrage and the election of governor and senators by electoral college. It was the first state west of the Allegheny Mountains admitted to the Union—June 1, 1792. In 1939 it ranked among the first thirteen states in the production of oil.

House in Bardstown, Kentucky, where in 1853, Stephen Foster wrote "My Old Kentucky Home."

● In the development of chemical services for oil and gas wells Dowell's list of "firsts" firmly establishes it as the pioneer and pace setter.

INHIBITED acidizing, introduced in 1932, was Dowell's first contribution. This development alone completely revolutionized production practices in limestone areas. Following it, to mention a few others, were Intensified Acid for dolomitic formations, Retarded Acidizing for fast-acting limestones, Formation Plugging for control of gas/oil ratios, the Acid Jet Gun for more effective results through accurate placement of the treating acid. Because every facility at its command is dedicated to a policy of constant research and advancement, other important Dowell developments will follow.

DOWELL INCORPORATED

Executive Office: MIDLAND, MICH. • General Office: KENNEDY BLDG., TULSA, OKLA.

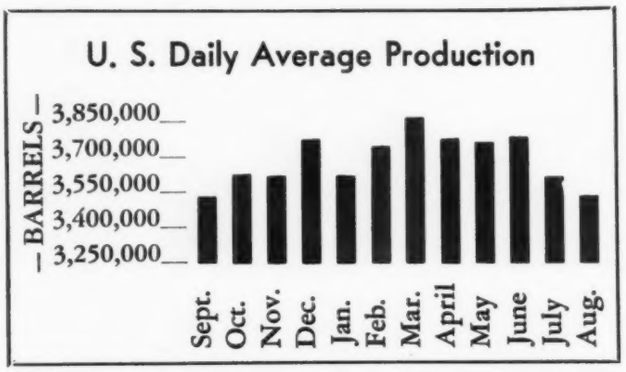
Subsidiary of The Dow Chemical Company

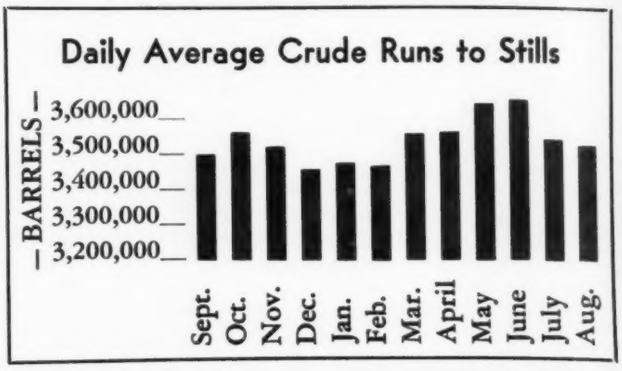
Look to

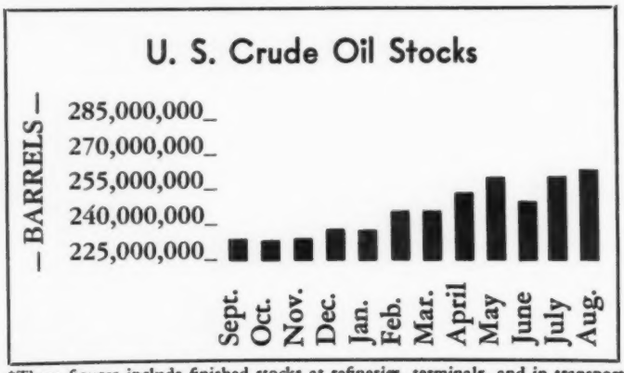
DOWELL

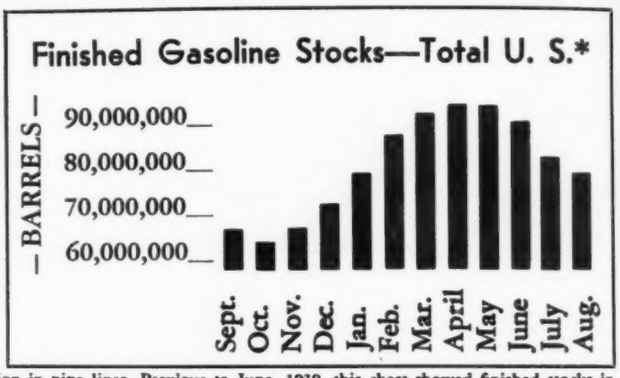
FOR OIL AND GAS WELL CHEMICAL SERVICE

Petroleum Statistics and Field Activities









*These figures include finished stocks at refineries, terminals, and in transportation in pipe lines. Previous to June, 1939, this chart showed finished stocks in refineries only. Above statistics by the American Petroleum Institute.

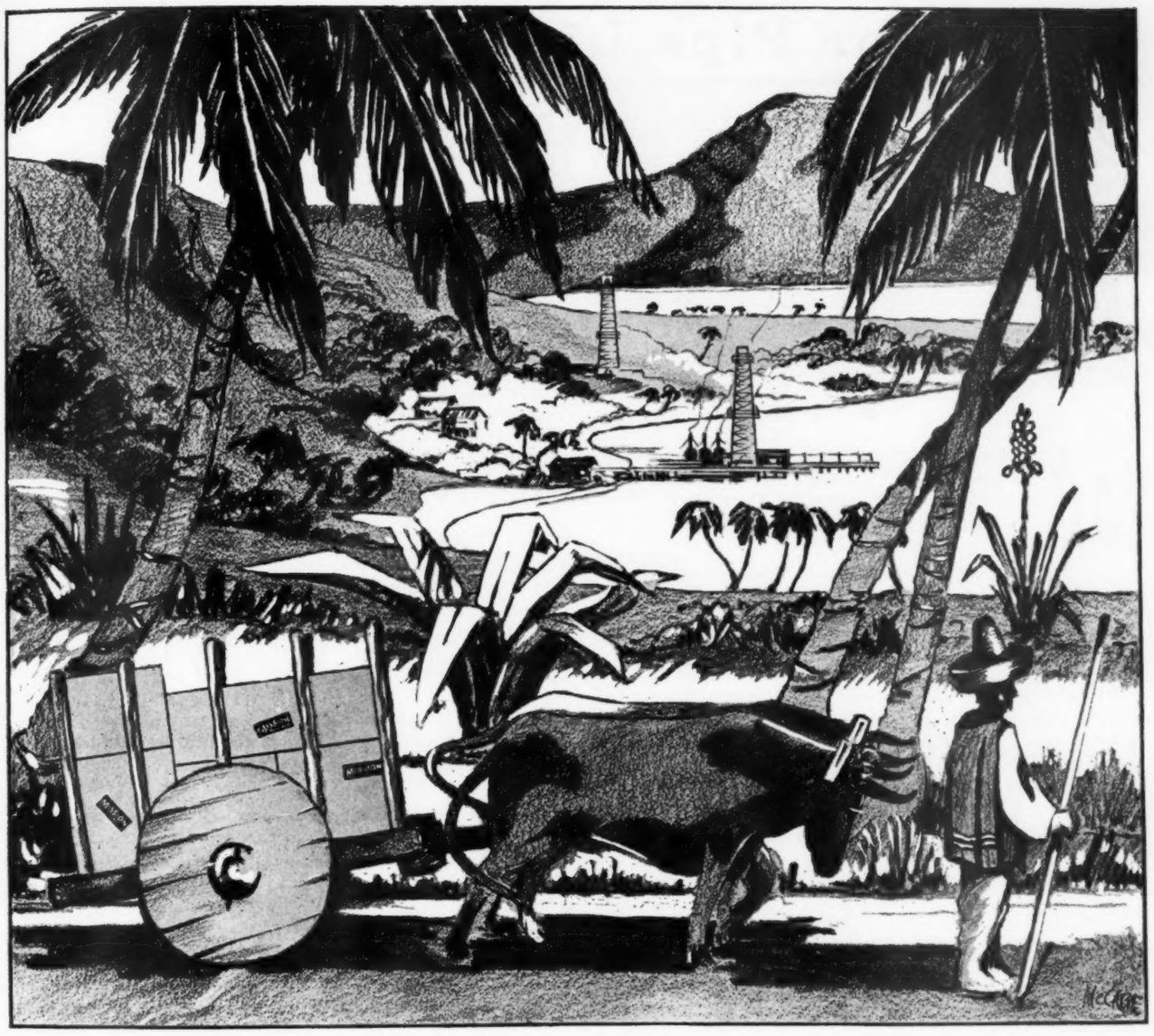
Summarized Operations in Active Fields for August, 1940

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas								
East Texas	26	25	5	14	3500-3700	2	40	Rotary
Duval County	27	13	6	16	1554-2900	2	22	Rotary
Ector County	43	43	18	45	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	71	69	20	72	1700-3900	2	40	Rotary
Refugio County	9	6	2	5	4900-5900	2	38	Rotary
Nueces County	16	13	3	6	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	19	19	12	42	3730-3935	2	42-43	Rot.-Cab.
Oklahoma								
Fitts Pool	16	13	3	7	1800-4488	2 or 3	38	Rotary
Kansas								
Russell County	25	24	7	17	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	8	7	5	14	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	21	19	5	21	3290-3518	2	39-42	Rot.-Cab.
Illinois								
Central Illinois	377	282	295	146	1425-4100	2	36-38	Rot.-Cab.
New Mexico								
Lea County	31	29	15	50	3150-4030	3	30-34	Rot.-Cab.
California								
Kettleman Hills	2	2	2	10	8300-8730	3 or 4	40	Rotary
Wilmington	20	20	12	12	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for August, 1940

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1939 (In Barrels)
	August	July	August	July	August	July	August	July	August	July	
Arkansas	13	12	7	7	10	17	6	6	27	33	21,266,994
California	105	112	97	100	88	85	76	92	171	175	224,336,682
Colorado	1	1	0	0	....	....	3	3	28	27	1,402,599
Illinois	377	340	282	251	404	506	295	290	146	141	92,915,620
Indiana	57	40	38	24	....	....	10	8	71	60	1,426,000
Kansas	197	193	165	157	197	185	36	40	238	235	59,952,340
Kentucky	37	33	17	12	....	....	11	6	80	82	5,611,500
Louisiana	128	146	103	106	135	113	33	32	164	176	94,110,736
Michigan	87	112	39	46	101	80	30	35	150	155	23,185,203
Mississippi	15	15	6	8	....	....	10	5	35	33	102,918
Montana	13	19	9	17	....	....	9	10	48	40	5,901,058
New Mexico	46	54	37	42	52	41	25	20	125	124	37,453,117
New York	78*	101*	78*	101*	....	....	11	10	65	66	5,105,000
Ohio	85	54	63	41	....	....	52	54	180	187	3,157,500
Oklahoma	179	166	127	88	184	134	42	40	270	265	156,421,939
Pennsylvania	282*	184*	268*	180*	....	....	....	....	....	....	17,342,500
Tennessee	....	....	....	....	....	....	....	....	....	....	....
Texas	821	856	622	678	833	859	375	404	1252	1301	485,847,999
West Virginia	33	46	28	36	....	120	25	21	144	135	3,556,500
Wyoming	16	16	12	10	....	....	10	9	75	67	21,408,478
Total	2554	2500	1998	1904	2017	2140	1059	1085	3269	3302	1,260,504,683

*Includes water-intake and pressure wells.



In Every Oil Country

THE HIGHEST TESTIMONY that is paid Mission "Rolling Dog" Slips is their outstanding preference all over the world. Wherever there is oil you will find Mission Slips handling pipe quickly, safely and economically.

Instant release of the pipe is assured. The dogs roll away from the pipe as it is lifted, releasing the pipe even when the slips are stuck in the bowl. Round trips are made quickly — smoothly — because delay in releasing stuck slips is eliminated.

Pipe is protected from excessive tooth marking by small, non-continuous slip teeth. Ample gripping area of Mission Slips prevents bottlenecking even under extreme loads. Your string is *safe* when it is supported with Mission "Rolling Dog" Slips.

Your Mission "Rolling Dog" Slips handle pipe faster — safer. Use them for drill pipe, casing, tubing, and be assured of maximum safety and economy.

MISSION MANUFACTURING CO.
HUMBLE ROAD, HOUSTON, TEXAS

Major Pipe Line Activities

DEMPSEY-WILSON Construction Company, Tulsa, Oklahoma, has begun construction of 100 miles of 20-in. line for the Natural Gas Pipeline Company of America between Geneseo and Belvedere in Illinois. This is a part of the extension program to Milwaukee whereby Natural Gas Pipeline Company of America will serve the industrial district of the Wisconsin metropolis.

Early this month bids were received on the 62-mile extension from Belvedere to Milwaukee, which will complete the project.

The gas supply will be from the Panhandle area of northwest Texas, western Oklahoma, and southwest Kansas.

●

Stanolind Pipe Line Company has announced plans for the laying of 180 miles of 12-in. crude oil pipe line. Of this total, 165 miles will be laid from La Plata, Missouri, to Wood River, Illinois, and 15 miles will be a loop on the main line southwest of La Plata.

The project is being undertaken for the purpose of supplying crude oil to the refinery of the Standard Oil Company of Indiana at Wood River, Illinois.

●

Williams Brothers Corporation is laying 200 miles of 4½-in. O.D. gasoline pipe line from Fort Worth, Texas, to Oklahoma City, Oklahoma, for the Magnolia Petroleum Company. The line is being welded and laid along the right-of-way of Magnolia's crude oil line.

Two crew stations have been established, one at Norman and one at Healdton, Oklahoma. Construction crews headquartered at these points are working toward each other.

J. R. Horrigan, head of Williams Brothers' Houston, Texas, office, is in personal charge of the work.

●

The City of Milwaukee has filed with the Federal Power Commission a petition to intervene in the proceedings concerning application of the Independent Natural Gas Company (Phillips Petroleum Company subsidiary) for a certificate of public convenience and necessity for construction of a natural gas pipe line from the Texas Panhandle to Milwaukee. The intervening petitioner claims interest in the matter on the grounds, among other things, that other natural gas pipe line proposals are pending.

In addition to the proposal of Western Natural Gas Company to construct a line from the Hugoton fields in Kansas to Milwaukee, the petitioner states, The Natural Gas Pipeline Company of America has entered into contracts for the construction of a pipe line from its present line at a point near Geneseo, Illinois, into the state of Wisconsin and into the City of Milwaukee. This company, according to the petitioner, claims that it is not subject to the authority or regulation of the Federal Power Commission or any other federal or local state regulatory body and that such a pipe line may be constructed without obtaining a certificate or permit from the commission.

The Independent Natural Gas Company, with main office at Bartlesville, Oklahoma, has applied to the commission for a certificate relative to its proposed natural gas pipe line extending from Sherman County in Texas to Milwaukee, a distance of 877 miles, at an estimated cost of $28,698,000. Part of the gas would be sold to Milwaukee Gas Light Company, the utility serving that city.

National Refining Company is adding 57 miles to its pipe line system in eastern Kansas. The new 8-in. line will connect with the company's Hoosier station in Cowley County and extend to Coffeyville, Kansas, where National has a refinery. The company already has a 4-in. line from Hoosier station to Coffeyville and when the 8-in. is completed the 4-in. will be taken up between Hoosier and Elgin, Kansas.

Oklahoma City, Burbank, and western Kansas crude oils will be transported through the new line. National Refining Company has connections for receiving deliveries of Oklahoma crude oil from the Standish Pipe Line Company and western Kansas crude oil from the Kaw Pipe Line Company. The contract was let to Williams Brothers Corporation.

●

The Lone Star Gasoline Company is laying a 45-mile pipe line from the Page field, Schleicher County, Texas, to San Angelo, Texas. The line is being laid for the Cooper Gas Company, which has a contract to supply gas to the West Texas Utilities Company's plant at San Angelo. The plant consumes from 3,000,000 to 5,000,000 cu. ft. of gas per day. The line is expected to be completed some time in October.

●

Early this month Gulf Refining Company placed in operation 18½ miles of 6-in. line from the K.M.A. field to Burkburnett, Texas. The capacity of the system is 10,000 bbl. per day.

Stanolind Pipe Line Company also has completed an outlet from the K.M.A. field. To take crude oil output from 225 wells, 35 miles of gathering line was laid and 11 miles of 6-in. from the field station to a point near Electra.

●

The Texas-New Mexico Pipe Line Company has awarded a contract to the Latex Construction Company for the laying of a pipe-line outlet from the Duggan and Slaughter fields, west Texas, to Midland. The line will consist of 82½ miles of 8⅝-in., 19 miles of 10¾-in., and 4 miles of 14-in. pipe.

The line is scheduled for completion by the middle of December and its capacity will be 8000 bbl. per day.

●

General Petroleum Corporation is laying a 14-mile, 6-in. pipe line from the Cole Creek field, Natrona County, Wyoming, to the Socony-Vacuum Oil Company's White Eagle refinery south of the field.

●

H. C. Price Company, Bartlesville, Oklahoma, has been awarded the contracts for electric welding on the following pipe lines:

For Magnolia Pipe Line Company, 17 miles of 6-in. and 8-in. near East St. Louis, Illinois; general contractor, Sheehan Pipe Line Construction Company.

For Natural Gas Pipeline Company of America, 100 miles of 20-in. from Geneseo, Illinois, to Rockford, Illinois; general contractor, Dempsey-Wilson Construction Company.

For National Refining Company, 57 miles of 8-in. from Cedarvale, Kansas, to Coffeyville, Kansas; general contractor, Williams Brothers Corporation.

P 425.215

THE Petroleum Engineer

SEPTEMBER, 1940

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Importance of Drill-Pipe String in California Deep Drilling

Design and the intelligent application of the drill-pipe string and its component parts influence drilling practice

By WALLACE A. SAWDON
Pacific Coast and Foreign Editor

THE high degree of efficiency attained in deep-drilling operations in California has been influenced to a considerable extent by the attention paid to the drilling string and its component parts. Advanced metallurgy has supplied material of adequate strength and hardness; design has utilized the material for effective performance and long life, and drilling technique has applied the designs to consistently successful application in meeting the conditions encountered. The result has been fast, straight holes to depths of more than 13,000 ft.

In a resumé of drilling string practice given recently[1] it was brought out that a trend is evident toward the use of $5\frac{9}{16}$-in. drill pipe to 8,000, even 10,000 ft. in deep fields where high rotating speeds are being used. This size string has been found most desirable for table speeds of 400 r.p.m. and greater and 4½-in. drill pipe is the smallest size used for comparatively high speeds to 400 r.p.m.

Large volumes of circulating fluid are necessary for deep-drilling operations and although relatively high pressures must be expected it is desirable to keep the pressure down as much as possible. Large-capacity pumps are used, the maximum size being 15½ by 9¼ by 22, which will deliver 1450 gal. per min. when equipped with 9¼-in. liner and running at a speed of 60 s.p.m. Although most pumps in service are not this large, two of whatever size is being used are generally available for circulating and the volume of fluid that can be pumped under desirable pressures is more or less limited by the flow capacity of the drill string, not considering the fluid ports through the bit, which are the same for any size drill pipe used. One pump, however, will provide the circulating capacity for almost all conditions encountered and the two pumps are seldom in circulating service at the same time except when it is necessary to compound them to gain pressure.

At the present time the pumping rate of circulating fluid probably never exceeds 1000 gal. per min. below 10,000 ft. and this gives a velocity through $5\frac{9}{16}$-in. drill pipe of 17.3 ft. per second.[2] The velocity of the fluid at the same rate of pumping upward through the annulus in 11-in. open hole is approximately 4.5 ft. per second but as the hole size is usually a little larger, this can be considered the maximum velocity obtained behind the pipe. One company has found that by using the $5\frac{9}{16}$-in. drill pipe to 10,000 ft., a pressure of 1600 lb. per sq. in. need not be exceeded to give a pumping rate of 900 gal. per min. under conditions encountered in the San Joaquin Valley field. The fluid is circulated in this case by two 8½ by 20 pumps compounded and it is estimated that 1800 lb. per sq. in. would be required for proper circulation through a full string of 4¼-in. drill pipe at this depth. The velocity of the 900 gal. per min. through $5\frac{9}{16}$-in. drill pipe is 15.6 ft. per sec. and through 4½-in. is 23.5 ft. per sec. The returns through 11-in. hole around the larger pipe is approximately 4.1 ft. per sec. and around the smaller pipe 3.6 ft. per sec.

The average pumping rate of mud fluid is probably between 700 and 800 gal. per min. in deep wells and the velocity behind the drill pipe at that rate is more than adequate for carrying up the cuttings from any formations encountered in the California fields. The high rotating speeds with only a small amount of weight carried on the bit are believed to result in much finer cuttings that are more readily circulated-out of the hole. Cleaning-out the cement after cementing the water string and drilling-in of the sand is usually done with 3½-in. drill pipe and the pumping rate is, of course, much less than when drilling

[1] "Advancements in Drilling Technique in California," by Wallace A. Sawdon, *The Petroleum Engineer*, Midyear, 1940.

[2] Velocity figures are taken from *The Petroleum Engineer's* Continuous Tables.

the larger hole in which the casing is set.

The effect of mud fluid circulation on the rate of penetration is the subject of research work at the present time. In the majority of the deep fields some form of drag bit is generally used for surface drilling and rock bits for most of the drilling below an average of 5000 ft. In fields such as Rio Bravo, rock bits are used exclusively. Except when drilling through hard strata, the hydraulic or jetting action of the fluid passing through the circulation ports of the bit is believed to have a very definite influence on the rate of penetration. Inasmuch as an appreciable amount of the footage drilled consists of formation on which hydraulic action is effective in varying degrees, the fluid circulation is a factor to consider. The combined area of all the holes in a bit is so much smaller than the bore of the drill pipe that the velocity through the ports is high with even the average pumping rate being used. Increased pumping rates obviously increase the velocity through the bit ports and may thus have a decided effect on the drilling speed in particular formations. Cleaning the teeth of a rock bit is, of course, a primary purpose of the high velocity fluid issuing from the circulation ports and is probably of greatest importance in those formations where hydraulic action is likely to be most effective, thus giving a combined reason for increased pumping rate through such formations.

Drill Pipe and Tool Joints

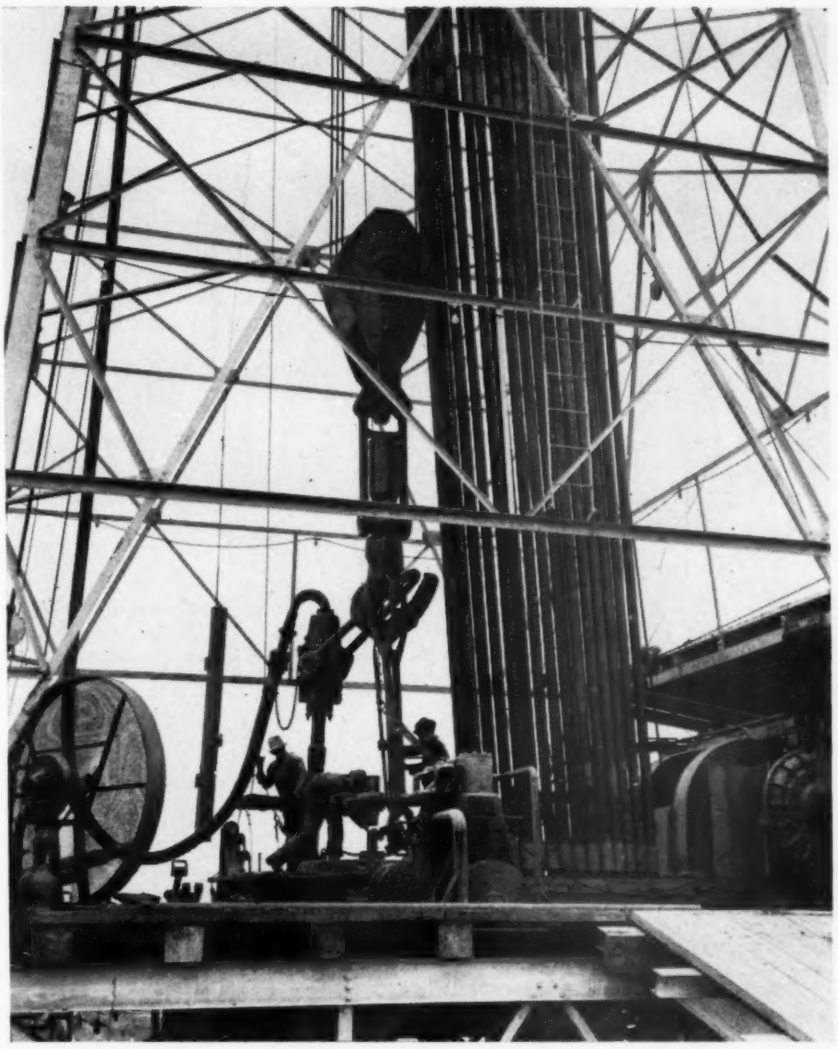
The drill string is, however, more than a means of carrying the circulating fluid to the bottom of the hole. Through it the power developed at the surface is carried to the bit where the actual digging is done; and in addition to providing a torque tube of great strength its component parts, consisting of lengths of drill pipe and tool joints, must carry its own ever-increasing weight, withstand torque loads and other stresses, and resist fatigue and abrasion to the greatest extent possible. The drill pipe of standard specifications now made available by manufacturers has proved to be adequate for any duty yet placed upon it although special alloy steels are widely used for many of the deep drilling operations. High-alloy drill pipe, although costing more, is selected from a purely economic standpoint and the long life of a number of such strings employed during the last two years has indicated that the special alloy pipe may be economical under many conditions. The tool joints must, of course, be consistent with the rest of the string so far as strength is concerned. Various factors enter into tool joint design, however, and probably most of the special types now being manufactured are in service in California.

The drilling program and down-hole conditions necessarily influence the kind of joint employed. Although external upset, internal flush joints are generally better for the smaller drill pipe sizes and internal and external upset for the larger sizes, high pumping rates will favor the internal flush joint, and heavy duty will favor the internal and external upset. The external flush joint provides an advantage, of course, when clearance is small and when drilling through blowout preventers or packers.

Although the A.P.I. regular, full-hole, and internal flush types of tool

Unitized drill stem equipped with new-type protectors

The fast drilling of deep holes is facilitated by use of heavy, up-to-date drilling equipment



joints are widely employed, the special designs now being used extensively aim to meet more specifically the exacting demands of modern rotary drilling, especially in deep-hole operations. More than ever it is necessary to obtain a connection with the drill pipe that will reduce to a minimum the chances of wash-outs, failure of the last engaged thread, and creepage during drilling. Alignment and concentricity of drill pipe joints, always desirable qualities, are particularly important with high-speed rotation, to help reduce the chance of whipping. Screwed A.P.I. pipe-to-joint connections are bucked-on and it has become general practice to weld these joints as well as buck them on the pipe.

Of the special types of tool joints, most are made available with any make of pipe although some are supplied only on the drill pipe made by manufacturers of the joint. With screwed pipe-to-joint connection, the shrinkage process is sometimes used to advantage in making-up both the box and pin ends on the pipe. One tool-joint design that has been widely used has only two thread connections including the joint for making-up the string. One end of each pipe length in this type is upset and threaded to take the pin end that is screwed on to the mating end of another pipe length. The newest type tool joint to be introduced is supplied with only one set of thread connections, that for making up the string. The box and pin ends of the joint are electrically welded to upset ends on the drill pipe.

Drill Collars and Weight

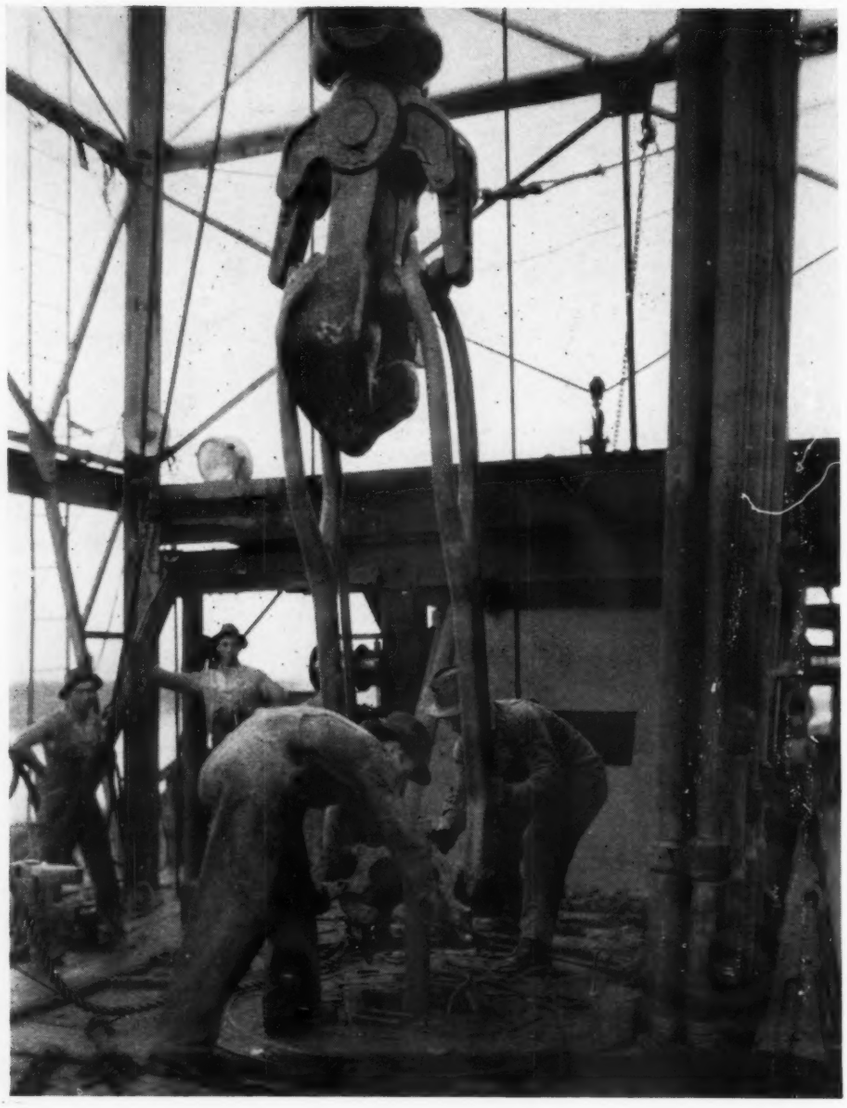
A 10,000-ft. string of drill pipe, including the drill collar, may weigh 150,000 lb. but it is obvious that only a very small percentage of this weight can rest on the bit while drilling. The advantage of concentrating the weight actually on the bit at a point as near the top of the bit as possible is well recognized and has resulted in the use of long, heavy drill collars in order to keep the greatest part of the string in tension. This practice has probably been one of the biggest factors in getting straight holes. The desirable plumb-bob effect thus obtained increases in importance as rotating speed increases and has permitted greater weight on the bit than would otherwise be possible at high speeds.

Excessively long drill collars have been used in drilling some wells but it seems apparent that extra weight in the string above the neutral point, i.e., in that portion of the string that is in tension, may offset some of the advantages derived from the concentrated weight at the bottom of the string. A very long collar becomes flexible and whipping may develop in the collar itself. The length of the drill collar should, however, be sufficient to provide a weight at least equal to the maximum weight to be put on the bit. As an example, a 240-ft., 8¼-in. drill collar weighing approximately 18 tons has been used with considerable success in wells drilled in the Rio Bravo field on which rotating speeds as high as 700 r.p.m. were employed, with the total weight of 18 tons applied to the bit.

Particular attention is being paid to design of drill collar in order to obtain the highest degree of alignment and straightness in the total assembled length. Until recently 60-ft. drill collar lengths were generally used for long collars in order to keep the number of joints to a minimum and thus eliminate misalignment and bends as much as possible. These long joints were difficult to transport and handle. Better joint design has now made this precaution unnecessary and 40-ft. lengths are more generally employed.

Concentricity of the bore in drill collars is carefully checked. Wall thickness is kept by the manufacturers to a variance of not more than ¼ in. from the theoretically correct figure and the tolerance on the bore is held to close limits. High rotating speeds especially necessitate accurate alignment and the maximum misalignment is limited to not more than ½ in. in 40 ft. The straightness is held to within ⅛ in. of true at any point throughout the entire length of the drill collar.

Drill collars used with $5\frac{9}{16}$-in. pipe are generally as large as 8-in. diameter although some have been slightly larger; those used with 4½-in. pipe are as large as 6¼-in. diameter, and



Making a trip with a string of modern drill pipe

those used with 3½-in. pipe are seldom larger than 5-in. diameter. Although it is easier to handle the 40-ft. lengths of drill collar, considerable care is taken in their transportation and scabbards are utilized for their protection.

High rotating speeds also necessitate attention to concentricity and alignment in the kelly and have advanced the use of octagonal and hexagonal types of kelly. The choice between the octagonal and hexagonal shapes seems to be based mainly on individual preference inasmuch as the hexagonal appears to offer about the same advantages as the octagonal with less chance of wear on the corners. The square kelly is, of course, still used extensively but the polygonal types provide additional advantages when it is desired to have a more unrestricted flow of circulating fluid from the swivel to the bit. The 5-in. hexagonal kelly, for example, has as large an opening as a 6-in. square kelly. The present practice when driving with the hexagonal type is to use a 5¼-in. kelly with 4½-in. drill pipe and 7⅝-in. with $5\frac{9}{16}$-in. drill pipe, the kelly being measured over flats. Practically all types of kellys now in use are supplied with welded-on upset joints.

Effect on Deviation

The drill strings now being used in deep-well operations in California provide the maximum opportunity for straight, fast drilling. Made-up as described above and rotated with the proper weight (for the rotating speed and formation) concentrated as close to the bit as possible, whipping has been reduced to a minimum. Rubber protectors and stabilizers are almost universally employed on that portion of the drill pipe that is rotating in casing; and although this may be only the short distance of 2000 to 3000 ft. or even less through the surface string in a well that will be drilled to depths as great as 11,000 ft., the protection of the casing and drill pipe by protectors has the added advantage of reducing whip in the upper portion of the string.

The protectors or stabilizers are now made of a tougher material that was originally developed for drilling through and below very abrasive formations in open hole. Although not generally applied for the purpose, protectors have been used to advantage on drill pipe in open hole in the East Coalinga Eocene field to protect the pipe and tool joints from the abrasive action prevalent at approximately 1400 ft. in some parts of the area. These protectors are employed for protection of the drill string and as high-speed rotation is not employed in drilling the wells the stabilizing effect is not so important.

It has become the practice to take readings for deviation at periodic intervals of depth in order to keep the hole straight at all times. There is no hard and fast rule for the intervals between readings but a number of companies take them at each connection, which makes the average approximately a little more than 40 ft. Other operators take the reading less frequently but it is recognized that a reading too far distant from the last may not be of sufficient value as the readings should be considered in sequence to give the proper control data.

The recording instrument is run in the drill pipe on a wire line or dropped into the pipe as a go-devil. When taking a reading at intervals as frequent as is now general practice it is necessary to use the line inasmuch as round trips are not made as often as the reading is taken. In most of the deep wells the wire line is used all the way to the cementing point of the water string, which is frequently below 11,000 ft. Some operators take an additional reading just before pulling-out even if a reading with wire line has been taken but a very short time before. As wells get deeper and bits make runs of only from 40 to 50 ft., the go-devil type of instrument is more frequently used as the interval between readings is then not much greater than those taken with the line during drilling farther up the hole.

Vapor-Liquid Phase Equilibria in Hydrocarbon Systems

Part IX

Calculations of the minimum reflux

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IN THE last installment the approximate minimum reflux for the separation outlined in Table 9 was computed as $L/V = 0.641$. It was stated that this value is an approximate value and somewhat higher than the actual minimum reflux because the computation of the approximate minimum reflux as previously described does not make proper allowance for the fractionation taking place between the zone of constant composition and the feed plate or for the differences between feed and feed plate. In the present installment a method of calculating the minimum reflux is described that properly considers the fractionation taking place between the zones of constant composition and the differences between the feed and feed plate. It consists of a cut-and-try solution using plate-to-plate computations with the arbitrary introduction of the missing components in a manner similar to that described for the computation of minimum plates in Part VII.

The method can best be explained by continuing the computations for the separation of Table 9 at minimum reflux. The compositions in the zones of constant composition in the rectifying and stripping sections of the column are given in the last column of Tables 15 and 16, respectively, for an assumed minimum reflux ratio, (L/V), of 0.615, (L = 0.65 for 1 mole of feed).

Having available the composition in the zone of constant composition above the feed plate and also in the zone of constant composition below the feed plate, plate-to-plate computations between the two zones are made as follows:

Referring to Table 17, column 3 gives the number of moles of ethane, propane, *iso*butane, and normal butane as computed for the zone of constant composition above the feed plate by multiplying the mole fraction given in the last column of Table 15 by 0.65, and arbitrarily adding a small quantity each of *iso*pentane and normal pentane in the proportions indicated.

Photographs and biographical sketches of the writers can be found on page 31 of the July issue of *The Petroleum Engineer*, in connection with Part VII.

This is substantially the procedure that was suggested some years ago by Lewis and Matheson[1] for making the adjustment between the composition computed downward from the top of the column and upward from the bottom.

The exact quantities added are of little or no significance in a computation for minimum reflux* it being only necessary to get the missing components into the liquid in small quantities so that the computation can be continued downward from the zone of constant composition as indicated by columns 3, 4, 5, 6, and 7 in Table 17.

Equation (39) is used to compute the vapor rising from plate $n + 1$ to plate n by a material balance around the top of the column with results given in column 4. As the pentanes are wholly absent in the overhead distillate ($Dx_D = 0$) as indicated in column 2, the quantity of pentanes is the same in the vapor rising to plate n from $n + 1$, ($Vy_n + 1$) as shown in column 4, as in the liquid overflowing from plate n, (Lx_n) shown in column 3. The quantities in the liquid overflowing from plate $n + 1$ are then determined by an equilibrium computation using equation (34) with each term multiplied by V.† The equilibrium constants for plate $n + 1$ are listed in column 5 and the summation of the terms ($V\frac{y}{K}$) of column 6 equals the summation of the terms (Vx) = 1.0581. The quantities of column 7 are obtained by multiplying those of column 6 by L/V (in this case 0.615). Plate-to-plate computations are then carried downward in the same manner as described and summarized in the subsequent columns of Table 17.

After carrying the plate-to-plate computations in this manner for about five plates, a small amount of "hexanes plus" is similarly and arbitrarily introduced (column 15) and the computations continued until a total of about eight plates is covered as outlined in Table 17.

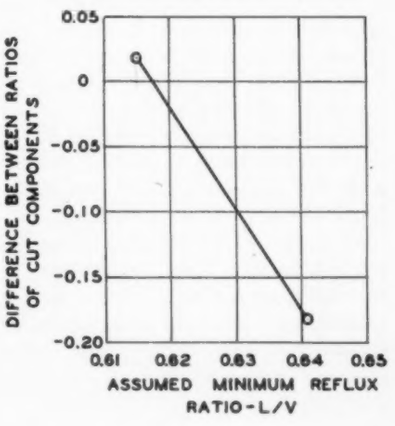
Similar computations set forth in Table 18 are made beginning with the zone of constant composition below the feed plate. In column 3 of Table 18 the number of moles of *iso*butane,

[1] *Ind. and Eng. Chem.*, Vol. 24, No. 5, p. 494 (1932).

*Any change in the quantities of less volatile components arbitrarily added at this point would merely effect a change in the number of plates in the plate-to-plate computation. In making a computation for minimum reflux, the number of plates is infinite and the significant result is the matching of the compositions at the feed plate as determined by the assumed minimum reflux.

†The use of equation (34) in this form eliminates a step in the computations and gives exactly the same results as the original equation (34) but the summation of the terms equals V instead of unity as in the original equation. In this case V = 1.058.

Fig. 20. Graphic determination of actual minimum reflux ratio



normal butane, *iso*pentane, normal pentane, and "hexanes plus," are obtained by multiplying the mole fraction in the zone of constant composition below the feed plate, as given in column 8 of Table 16, by K (column 3, Table 16) and by V (in this case 1.058), and arbitrarily adding a small quantity of propane.

Plate-to-plate computations upward from this point are made by making material balances around the bottom of the column (equation 40) and assuming equilibrium between the liquid and vapor on each plate in a manner similar to that described for the upper or rectifying part of the column but using equation (35) multiplied by $\overline{L}$, which in this case is 1.65.

These computations are continued for about ten plates, at which point a small quantity of ethane is arbitrarily added as shown in column 23 (Table 18). Computations are then continued upward as summarized in the latter part of Table 18.

Comparison of the quantity of each component in the vapor, Vy_{n+8}, shown in the last column, 22, of Table 17, with that in the vapor, $\overline{V}y_{m-14}$, shown in the last column, 33, of Table 18, indicates a very satisfactory agreement in the number of moles of all components more volatile than normal butane.

Because the ethane and propane as computed upward from the bottom of the column, as shown in column 33 of Table 18, are in agreement with the ethane and propane as determined by computing downward from the top of the column, as shown in column 22 of Table 17, on the same plate on which the cut components are almost in agreement, (the *iso* and normal butane, of column 33, Table 18, and of column 22, Table 17) it is indicated that the arbitrary introduction of propane and ethane on plates m — 1 and m — 10, respectively, as indicated in Table 18, is substantially correct and no further adjustment in these compounds is required. Because the pentanes and "hexanes plus" fractions as computed downward from the top of the column (given in column 22 of Table 17), are not in close agreement with the corresponding quantities determined by computing upward (column 33 of Table 18), the arbitrary introduction of these components in the computations of Table 17 is not quite correct and some adjustment in the pentanes and "hexanes plus" must be made in the computations for the rectifying section of the column.

The purpose of introducing these components in the computations of Table 17 is to determine what effect their presence might have on the temperature and the fractionation between *iso*butane and normal butane between the zone of constant composition and the feed plate. The computations of Table 18 may be extended upward to the next plate, which is the plate above the feed plate, designated plate f — 1, in the manner set forth in the first few columns of Table 19. In making this computation it must be remembered that the plate above m — 14 is a plate above the feed plate and the material balance, if made around the bottom of the column, must make proper allowance for the feed, which in this case amounts to 1 mole of liquid at its boiling point. The computations set forth in the first six columns of Table 19 have been made in this manner and the quantity of *iso*pentane, normal pentane, and "hexanes plus" shown in the vapor rising from the plate f — 1 in column 6 must be correct because they are based upon the known composition of these compounds in the bottoms product.

Because there is no *iso*pentane or normal pentane in the overhead distillate, the quantities of these materials in the liquid overflowing from plate f — 2 (or for this computation, plate n + 6) must be the same as the quantity in the vapor rising from plate f — 1 as shown in column 6. The total quantity of material in the liquid overflowing from plate n + 6 is given in column 7, Table 19. This is computed by adding to the ethane, propane, *iso*butane, and normal butane, as computed for plate n + 6 in Table 17 (column 17), the quantity of *iso*pentane, normal pentane, and "hexane plus" as computed for the vapors rising from plate f — 1 (column 6, Table 19).

These adjustments or changes in the compositions of the pentanes and hexanes shown in Table 19 are so small compared with the compositions for the corresponding plates computed in Table 17, that there is no necessity in continuing these adjustments farther up the column. The quantity of these adjusted components is sufficiently accurate because the total of all components is 0.656, within 1 percent of the correct amount, 0.65.

Computations are then continued from this adjusted plate n + 6 as given in column 7 of Table 19 working down the column in the same manner as set forth in Table 17 to obtain revised quantities for the vapor rising

TABLE 17

Plate-to-plate computations between upper zone of constant composition (plate n) and feed plate with arbitrary introduction of pentanes and hexanes for the assumed minimum reflux ratio, L/V = 0.615.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Plate		n		n+1			n+2		n+3		n+4		n+5		n+6				n+7		n+8
Temperature		160°F.		160°F.			160°F.		160°F.		161°F.		162°F.		164°F.				168°F.		188°F.
Component	$D x_D$	Liquid Lx_n	Vapor $Lx_n + Dx_D = Vy_{n+1}$	K at 215 lb. per sq. in. abs. and 160°F.	Vy / K	Liquid Lx	Vapor Vy	Liquid Lx	Vapor Vy	Liquid Lx	Vapor Vy	Liquid Lx	Vapor Vy	Liquid Lx	Vapor Vy	Liquid Lx	Vapor $Lx_{n+6} + Dx_D = Vy_{n+7}$	K at 215 lb. per sq. in. abs. and 168°F.	Vy / K	Liquid Lx	Vapor Vy
C_2H_6	0.0890	0.0151	0.1041	4.25	0.0245	0.0151	0.1041	0.0151	0.1041	0.0151	0.1041	0.0150	0.1040	0.0149	0.1039	0.0147	0.1037	4.43	0.0234	0.0144	0.1034
C_3H_8	0.2714	0.1708	0.4422	1.59	0.2782	0.1708	0.4422	0.1708	0.4422	0.1708	0.4422	0.1702	0.4416	0.1691	0.4405	0.1671	0.4385	1.69	0.2590	0.1593	0.4307
i-C_4H_{10}	0.0437	0.1533	0.1970	0.79	0.2490	0.1533	0.1970	0.1533	0.1970	0.1533	0.1970	0.1521	0.1958	0.1507	0.1944	0.1488	0.1895	0.85	0.2230	0.1372	0.1800
n-C_4H_{10}	0.0040	0.3105	0.3145	0.622	0.5050	0.3105	0.3145	0.3105	0.3145	0.3105	0.3145	0.3065	0.3135	0.3050	0.3090	0.2934	0.2974	0.675	0.4405	0.2710	0.2750
i-C_5H_{12}	0.000	0.000267	0.000267	0.31	0.000862	0.00053	0.00105	0.00053	0.00105	0.00208	0.00208	0.0041	0.0041	0.00801	0.00801	0.0152	0.0152	0.34	0.0447	0.0275	0.0275
n-C_5H_{12}	0.000	0.0000684	0.0000684	0.246	0.000278	0.000171	0.000428	0.000428	0.00107	0.00107	0.00263	0.00263	0.00647	0.00647	0.0153	0.0153	0.0153	0.273	0.0560	0.0344	0.0344
C_6H_{14}+	0.000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.00032	0.00032	0.00032	0.00047	0.00047	0.0435	0.0109	0.0067	0.0067
Total		0.6500	1.0581		1.0578	0.6504	1.0585	0.6512	1.0593	0.6528	1.0609	0.6535	1.0616	0.6542	1.0623	0.6520	1.0601		1.0575	0.6505	1.0586
Correct value for total		0.6500	1.0581		1.0581	0.6500	1.0581	0.6500	1.0581	0.6500	1.0581	0.6500	1.0581	0.6500	1.0581	0.6500	1.0581		1.0581	0.6500	1.0581

from plate n + 8 as set forth in column 12 of Table 19.

It will be noted that the temperature of plate n + 7 in Table 19 is 169°F. as compared with 168°F. for this plate as computed in Table 17. This difference is due to the different quantities of pentanes and hexanes on this plate, which quantities were not correctly introduced by the arbitrary introduction used in the calculation of Table 17. The discrepancy of 1°, however, is not sufficient to cause any significant difference in the compositions of the *iso*butane and normal butane as the arbitrary introduction of the pentanes and hexanes in Table 17 has been very close to correct.

In making these trial-and-error, plate-to-plate calculations, it is usually best to aim at an agreement between the compounds more volatile than the cut components and less volatile than the cut components, proceeding in the manner as outlined in Tables 17 and 18. When these components have been adjusted in this manner to a substantial agreement, as noted in the computations of Tables 17 and 18, the final adjustment may be made in the manner described in Table 19. The reflux ratio used is the correct minimum reflux for the required separation if there is also satisfactory agreement between the cut components in the vapor rising from the feed plate as computed downward from the top, (column 12 of Table 19) and computed upward from the bottom (column 33, Table 18). In these two tables the agreement in the *iso*butane is entirely satisfactory, but the agreement in the normal butane, while good, still leaves a little to be desired, and the reflux used in Tables 17, 18, and 19 is not quite the correct actual minimum reflux.

The normal butane as computed downward from the top of the column is about 3 percent less in quantity than is necessary to give the operation in the bottom of the column called for by the specified separation of Table 9. (See Fig. 19 for a plot of the compositions.) This means that the assumed minimum reflux ratio of 0.615 is not quite sufficient to accomplish the separation of Table 9 with an infinite number of plates. The fact that the ratio between the *iso*butane and normal butane in the feed plate vapors (column 12, Table 19) computed downward from the top is greater than the ratio between *iso*butane and normal butane in the feed plate vapors computed upward from the bottom (column 2, Table 19) when all the other components are in satisfactory agreement, indicates that a slightly higher reflux will be required to reduce this ratio coming downward from the top of the column so that the composition of the cut components will be the same as for computations upward from the bottom.

In order to determine the correct value for the actual minimum reflux it is necessary to repeat this series of

TABLE 18

Plate-to-plate computations between lower zone of constant composition (plate m) and feed plate with arbitrary introduction of ethane and propane for the assumed minimum reflux ratio, L/V = 0.615.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Plate		m-1	m-2				m-3		m-4		m-5		m-6		m-7	
Temperature		228.5°F.	228.5°F.				228°F.		227°F.		227°F.		227°F.		227°F.	
Component	Bx_B	Vapor $\overline{V}y_{m-1}$	Liquid $\overline{V}y_{m-1} + Bx_B = \overline{L}x_{m-2}$	K at 215 lb. per sq. in. abs. and 228.5°F.	$\overline{KL}x$	Vapor $\overline{V}y$	Liquid $\overline{L}x$	Vapor $\overline{V}y$	Liquid $\overline{L}x$	Vapor $\overline{V}y$	Liquid $\overline{L}x$	Vapor $\overline{V}y$	Liquid $\overline{L}x$	Vapor $\overline{V}y$	Liquid $\overline{L}x$	Vapor $\overline{V}y$
C_2H_6	0.000															
C_3H_8	0.000	0.00182	0.00182	2.5	0.00455	0.00292	0.00292	0.00468	0.00468	0.00747	0.00747	0.01193	0.01193	0.0190	0.0190	0.0303
i-C_4H_{10}	0.0368	0.3850	0.4218	1.425	0.6010	0.3845	0.4218	0.3830	0.4198	0.3795	0.4163	0.3780	0.4148	0.3745	0.4113	0.3720
n-C_4H_{10}	0.1895	0.5385	0.7280	1.155	0.8405	0.5380	0.7280	0.5355	0.7250	0.5305	0.7200	0.5280	0.7175	0.5245	0.7140	0.5210
i-C_5H_{12}	0.0732	0.0565	0.1297	0.68	0.0882	0.0565	0.1297	0.0560	0.1292	0.0554	0.1286	0.0551	0.1283	0.0549	0.1281	0.0548
n-C_5H_{12}	0.1208	0.0680	0.1888	0.563	0.1063	0.0680	0.1888	0.0676	0.1884	0.0672	0.1880	0.0670	0.1878	0.0669	0.1877	0.0669
C_6H_{14}+	0.1716	0.0140	0.1856	0.118	0.0219	0.0140	0.1856	0.0139	0.1855	0.0138	0.1854	0.0138	0.1854	0.0138	0.1854	0.0138
Total		1.0638	1.6557		1.6625	1.0639	1.6568	1.0607	1.6526	1.0539	1.6458	1.0538	1.6457	1.0536	1.6455	1.0588
Correct value for total		1.0581	1.6500		1.6500	1.0581	1.6500	1.0581	1.6500	1.0581	1.6500	1.0581	1.6500	1.0581	1.6500	1.0581

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Plate	m-8		m-9		m-10		m-11		m-12		m-13		m-14			
Temperature	225°F.		223°F.		221°F.		217°F.		212°F.		201°F.		188°F.			
Component	Liquid $\overline{L}x$	Vapor $\overline{V}y$	Liquid $\overline{L}x$	Vapor $\overline{V}y$	Liquid $\overline{L}x$	Vapor $\overline{V}y$	Liquid $\overline{L}x$	Vapor $\overline{V}y$	Liquid $\overline{L}x$	Vapor $\overline{V}y$	Liquid $\overline{L}x$	Vapor $\overline{V}y$	Liquid $\overline{V}y_{m-13} + Bx_B = \overline{L}x_{m-14}$	K at 215 lb. per sq. in. abs. and 188°F.	$\overline{KL}x$	Vapor $\overline{V}y$
C_2H_6						0.000786	0.000786	0.0028	0.0028	0.00976	0.00976	0.0326	0.0326	4.9	0.1600	0.1025
C_3H_8	0.0303	0.0480	0.0480	0.0748	0.0748	0.1157	0.1157	0.1743	0.1743	0.2545	0.2545	0.3460	0.3460	1.94	0.6700	0.4295
i-C_4H_{10}	0.4088	0.3645	0.4013	0.3525	0.3893	0.3375	0.3743	0.3145	0.3513	0.2835	0.3203	0.2370	0.2738	1.02	0.2780	0.1784
n-C_4H_{10}	0.7105	0.5105	0.7000	0.4955	0.6850	0.4745	0.6640	0.4460	0.6355	0.4070	0.5965	0.3505	0.5400	0.81	0.4365	0.2800
i-C_5H_{12}	0.1280	0.0540	0.1272	0.0525	0.1257	0.0507	0.1239	0.0480	0.1212	0.0446	0.1178	0.0386	0.1118	0.44	0.0492	0.0316
n-C_5H_{12}	0.1877	0.0656	0.1864	0.0636	0.1844	0.0615	0.1823	0.0585	0.1793	0.0540	0.1748	0.0468	0.1676	0.355	0.0595	0.0381
C_6H_{14}+	0.1854	0.0132	0.1848	0.0128	0.1844	0.0124	0.1840	0.0117	0.1833	0.0107	0.1823	0.0089	0.1805	0.061	0.0110	0.0070
Total	1.6507	1.0558	1.6477	1.0517	1.6436	1.0531	1.6450	1.0558	1.6477	1.0641	1.6560	1.0604	1.6523		1.6642	1.0671
Correct value for total	1.6500	1.0581	1.6500	1.0581	1.6560	1.0581	1.6500	1.0581	1.6500	1.0581	1.6500	1.0581	1.6500		1.6500	1.0581

TABLE 19

Revised plate-to-plate computations above feed plate for the assumed minimum reflux ratio of 0.615

1	2	3	4	5	6	7	8	9	10	11	12
Plate.....	m-14	f—1				n+6 or f—2	n+7				n+8
Temperature	188°F	169°F				164°F	169°F				188°F
Component	(Col. 33 Table 18) Vy_{m-14}	$Vy_{m-14} - Dx_D$ = Lx_{f-1}	K at 215 lb. per sq. in. abs. and 160°F.	KLx	Vapor Vy	Revised liquid Lx	Vapor Vy_{n+7}	K at 215 lb. per sq. in. abs. and 169°F.	$\frac{Vy}{K}$	Liquid Lx	Vapor Vy
C_3H_8	0.1025	0.0135	4.45	0.0600	0.0976	0.0147	0.1037	4.45	0.0233	0.0143	0.1033
C_3H_8	0.4295	0.1581	1.7	0.2690	0.4380	0.1671	0.4385	1.7	0.2580	0.1587	0.4301
i-C_4H_{10}	0.1784	0.1347	0.86	0.1159	0.1883	0.1458	0.1895	0.86	0.2200	0.1353	0.1790
n-C_4H_{10}	0.2800	0.2760	0.68	0.1878	0.3055	0.2934	0.2974	0.68	0.4370	0.2690	0.2730
i-C_5H_{12}	0.0316	0.0316	0.346	0.0109	0.0178	0.0178	0.0178	0.346	0.0514	0.0316	0.0316
n-C_5H_{12}	0.0381	0.0381	0.277	0.0106	0.0172	0.0172	0.0172	0.277	0.0620	0.0381	0.0381
C_6H_{14}+	0.0070	0.0070	0.044	0.0003	0.0005	0.0005	0.0005	0.044	0.0114	0.0070	0.0070
Total.....	1.0671	0.6590		0.6545	1.0649	0.6565	1.0646		1 0631	0.6540	1.0621
Correct value for total.....	1.0581	0.6500		0.6500	1.0581	0.6500	1.0581		1.0581	0.6500	1.0581

computations with a slightly greater assumed minimum reflux, until a perfect check is obtained in the quantities of all compounds as computed downward from the top of the column and upward from the bottom. As a practical means it is necessary to compute not more than three such assumed minimum reflux ratios, from which a plot may be prepared showing the differences in the ratios between the cut components in the feed plate vapors as computed downward from the top and upward from the bottom (or the difference in the quantity of normal butane as shown in column 33 of Table 18 and column 12 of Table 19) against the corresponding assumed minimum reflux. By drawing a smooth curve through these points the correct minimum reflux may be read at the point where there is no difference between the ratios (or the quantities of normal butane).

For the separations specified in Table 9 another similar computation was made for an assumed minimum reflux ratio of $L/V = 0.641$, which is the approximate minimum reflux computed for this separation (see installment VII). The results of this computation for the composition of the feed plate vapors as computed downward from the top of the column and upward from the bottom are set forth in Table 20. All components except the cut components match satisfactorily between columns 4 and 5, but this reflux ratio (0.641) is appreciably greater than the actual minimum so that it is impossible to obtain a satisfactory match in the case of *iso*butane and normal butane, the two cut components.

In Table 20 the ratio of *iso*butane to normal butane is much smaller as computed downward from the top of the column than computed upward from the bottom when all the other components have been brought into substantial agreement. This indicates than the value of 0.641 is greater than the actual minimum reflux ratio required for the separation set forth in Table 9.

A series of computations such as those just outlined could be made and the results plotted as in Fig. 20, wherein the value of L/V used in the calculations of Tables 19 and 20 has been plotted against the corresponding difference in the ratio of the cut components in the feed plate vapor computing downward from the top and upward from the bottom after the more volatile and less volatile non-distributed components have been brought into substantial agreement. From Fig. 20 the actual minimum reflux ratio is determined as 0.618.

The actual minimum reflux ratio, 0.618, is, in this case, about 3.5 percent less than the approximate value, 0.641, computed by the method of Brown and Martin. This difference appears to be less the sharper the separation.

Unless an accurate value for the actual minimum reflux is required for some special purpose, the approximate minimum reflux conveniently calculated by the method of Brown and Martin as described in the previous installment is usually satisfactory. The error in all computations made to date was on the safe side (the approximate minimum reflux being more than the actual minimum reflux) provided care was used to apply the method to that part of the column having the greater number of plates.

In the next installment a method will be explained for computing the number of equilibrium plates and the required reflux ratio by means of a convenient empirical relationship between reflux ratio, minimum reflux ratio, number of equilibrium plates, and minimum number of plates.

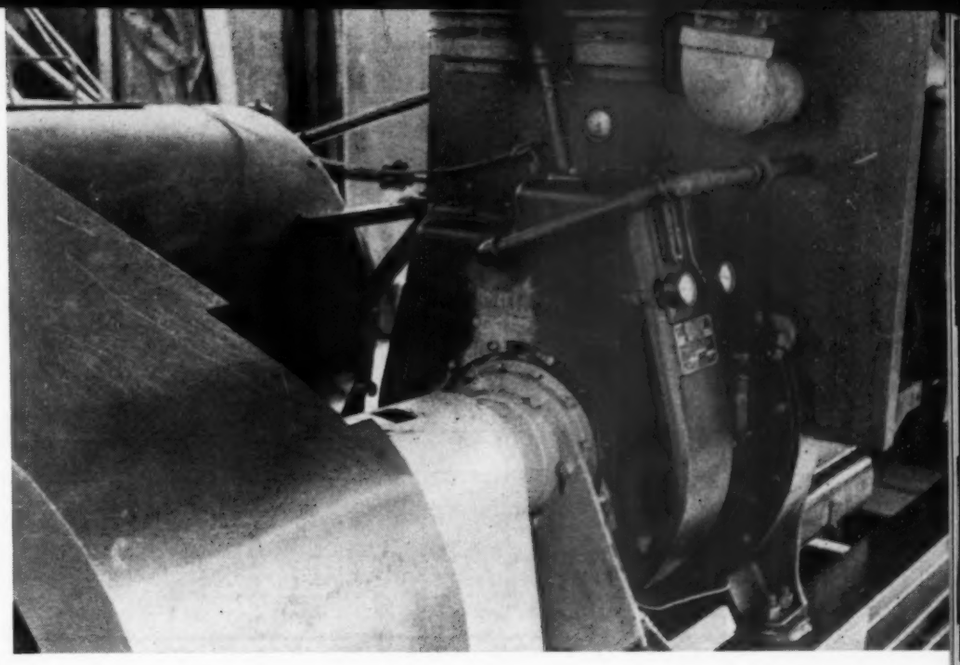
TABLE 20

Results of plate-to-plate calculations for the assumed minimum reflux ratio of 0.641 (L = 0.727 moles/mole of feed) using the same method as outlined for the assumed minimum reflux ratio of 0.615 (L = 0.65)

1	2	3	4	5
Temperature.....	164°F.	226.5°F.	188°F.	187°F.
Component	Moles of liquid in zone of constant composition above feed plate Lx_n	Moles of liquid in zone of constant composition below feed plate Lx_m	Feed tray vapor computed by working down from top of column Vy_{n+10}	Feed tray vapor computed by working up from bottom of column Vy_{m-18}
C_3H_8.....	0.0153		0.1037	0.1042
C_3H_8.....	0.1776		0.4356	0.4350
i-C_4H_{10}.....	0.1568	0.4780	0.1833	0.2170
n-C_4H_{10}.....	0.3373	0.7440	0.3390	0.3000
i-C_5H_{12}.....		0.1301	0.0324	0.0324
n-C_5H_{12}.....		0.1893	0.0390	0.0390
C_6H_{14}+.....		0.1856	0.0072	0.0072
Total.....	0.7270	1.7270	1.1402	1.1348
Correct value for total.	0.7270	1.7270	1.1351	1.1351

P 422.34

Torque converter and pedestal bearing installed between engine and V-belt sheave



A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By H. LEE FLOOD
Associate Editor

Hydraulic Torque Converter Used on Illinois Drilling Rig

Hydraulic drive increases flexibility of operation when internal-combustion engine power is used

NOT so many years ago, when drilling contractors were more inclined to "stay put" and operate only in a more or less restricted area, little thought was given to making the drilling equipment lighter and thus more mobile nor was it often that any material changes in the equipment would be required during its service life. As oil companies and major drilling contractors have grown and their activities have been extended to many areas scattered over thousands of miles, it has become commonplace practice to load an entire drilling assembly on trucks and move it considerable distances.

Most of the problems of streamlining and otherwise fitting even the heaviest equipment to stand such long journeys have been solved satisfactorily in most instances. When, however, as is often the case, different conditions are encountered in new fields, such as a shortage of water or when it becomes desirable to employ a different type fuel, it may become difficult or costly to operate a given type of rig and even more prohibitive to consider major changes in the equipment in order to obtain the desired advantages.

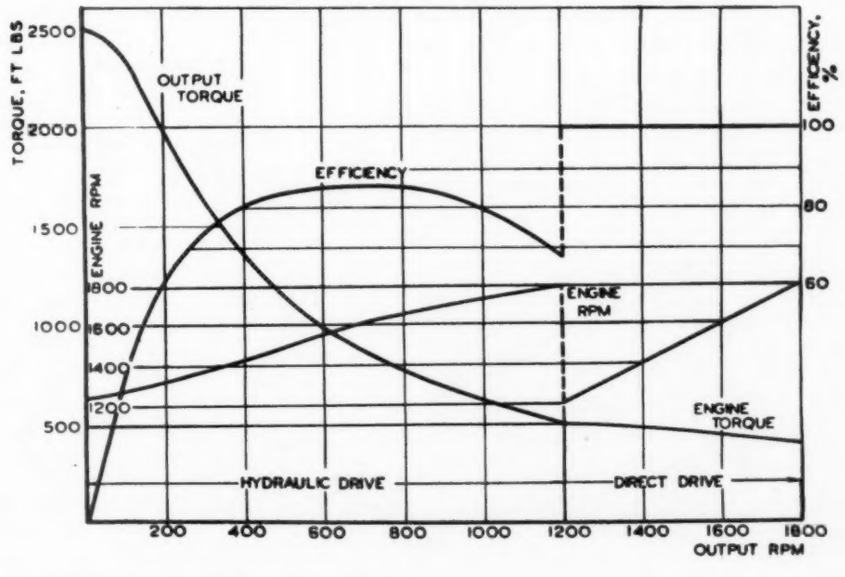
Drilling contractors and oil companies owning drilling rigs who moved equipment into the Illinois Basin from Oklahoma and Texas found, in many instances, that the machinery was entirely unsuited for the conditions encountered.

One company moved a medium-size steam rig to Illinois and operated it with fairly satisfactory results for more than a year. Only recently, however, it was decided that, rather than replace the wornout boilers with new ones, the rig should be converted to use internal-combustion engines if the change could be made economically. Other factors, of course, influenced the desire to change over, but it is doubtful whether the alteration would have been made if a conventional drive had been selected, making it necessary to purchase an entirely new multi-speed drawworks.

The important element that made the change from steam to internal-combustion engine power possible at reasonable cost was the hydraulic torque converter that was incorporated into the drive between the engine and the drawworks.

Torque converters of the type installed in this drilling application have been used in other industrial services where high torque at low speed is desirable momentarily. Use of converters

Fig. 1. Three-stage hydraulic torque converter performance characteristics (with direct drive)



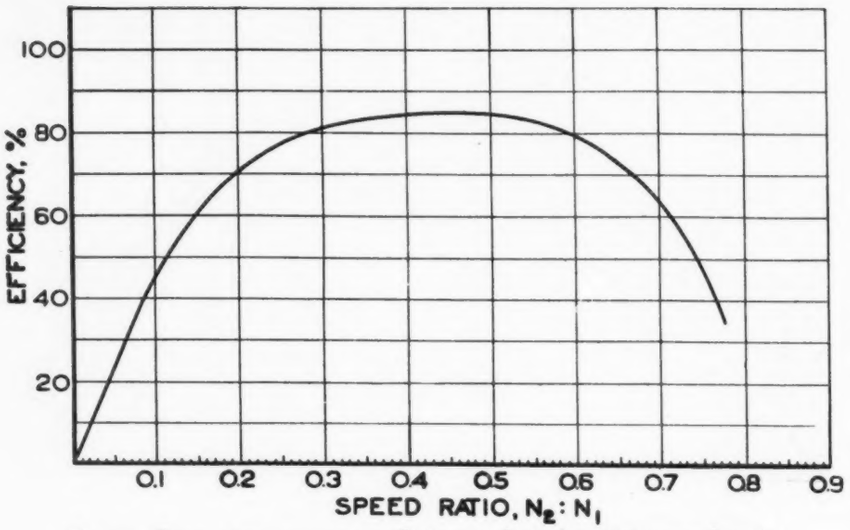


Fig. 2. Three-stage converter efficiency plotted against speed ratio

on drilling hoists is rather new, however, and it is believed that more information concerning torque converter performance should be made available to those responsible for drilling operations.

Application of Torque Converter to Drawworks

The torque converter is essentially a hydraulic chamber comprising a centrifugal pump and a reaction turbine. In the impeller or pump, as the fluid velocity increases, the fluid absorbs kinetic energy and thereby imposes a corresponding load on the engine or driving member. In the runner or turbine, due to loss of rotational velocity as the fluid is forced to the inside, kinetic energy is released and becomes available to the output shaft.

The capacity of the converter is based on hydraulic laws in accordance with which the horsepower is proportional to the cube of the speed, and the torque capacity is proportional to the square of the speed. Both horsepower and torque are in proportion to the 5th power of the diameter. These relations may be expressed as follows:

$$HP = C \times n^3 \times d^5$$

$$\text{Torque capacity } (T) = C \times n^2 \times d^5$$

Converter Performance

The hydraulic characteristics of a torque converter are such that the power absorbed by the pump (impeller) varies as the cube of its speed. The size of the impeller must therefore be selected to conform with the power delivered by the engine. The operating speed range of the output shaft of the converter is from zero, called the stalling point, to approximately two-thirds of engine speed. At the latter point, the torque available at the output shaft (the minimum delivered by the converter) is equal to the torque of the engine. These characters are shown in Fig. 1.

The efficiency of the converter is a direct function of the ratio of output to input speed and attains its maximum value when this ratio is approximately 0.5. The curve in Fig. 2 is characteristic of a 3-stage turbine type of converter. Even taking the loss of efficiency through the converter into full consideration, it has been demonstrated in actual installations that the ability to operate an engine continuously at its most efficient load-speed range results in economy of fuel consumption that offsets the efficiency loss of the converter.

If for light load operation, it is preferable to operate at reduced speeds, a group of torque and efficiency curves, as shown in Fig. 3, would be obtained. It will be noted that as the engine speed is reduced, for a corresponding output shaft speed, the efficiency curve moves to the left of the graph; thus indicating that for a specific ratio of output/input speed the converter efficiency remains constant. Consequently, it is possible to operate a converter at light loads and low speeds and maintain satisfactory efficiency.

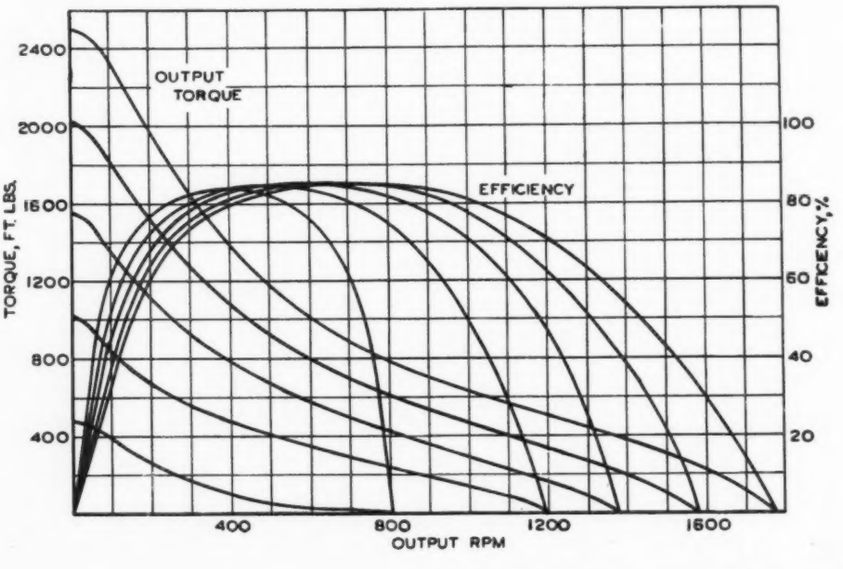
A study of the above performance characteristics will indicate that a converter can be applied advantageously when variable speed operation is required and when high torques at low speed are necessary for starting heavy loads—a requirement that constitutes the principal duty imposed upon a rotary drawworks.

Performance on Illinois Installation

Being the first torque converter to be installed by the company owning the rig being discussed, operation and performance of the converter has been closely watched. Results to date have shown that the converter permits flexibility of operation with the internal-combustion engine that compares favorably with steam-engine operation.

The only major change that has been made since the converter was installed has been to install a pedestal bearing on the shaft between the converter and the V-belt sheave driving the drawworks to avoid excessive bearing wear when the sheave was overhung. The equipment company servicing the converter recommended the change and is planning to equip all future converter-equipped engine units in this fashion.

Fig. 3. Partial throttle performance characteristics of a converter



P 615.635.4

Pipe-to-Soil Potentials in Cathodic Protection Systems

Data indicate potential of normal steel pipe to copper sulphate electrode approximates 0.54 volts—studies reveal voltage "build-up" is too erratic to be reliable

By WALTER F. ROGERS
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WALTER F. ROGERS

was born April 3, 1905, at Tyler, Texas — Graduated from Tyler High School in 1922—Graduated from University of Pittsburgh with degree of B.S. in chemical engineering in 1926—Received professional degree in chemical engineering from University of Pittsburgh in 1933—Began work for Gulf Refining Company at Port Arthur in 1926—Transferred to chemical laboratory of Gulf Oil Corporation, Houston, Texas, in 1927 where he is still employed—Has specialized in studies of corrosion of production and pipe-line equipment.

Theory of Cathodic Protection

THE natural process of corrosion of steel in soils is illustrated in Fig. 1. A corrosion pit is shown on the bottom of the pipe. This cell developed because a potential difference exists between two areas of the pipe. At the area of greatest potential (the anode) iron is forced into solution and the replaced hydrogen from the water plates-out on the area of lower potential (the cathode). The soil conditions governing the exact rate of this reaction are numerous and complex. Reduced to its simplest terms the flow of current between the anode and cathode will continue until their potentials are brought to the same value by the hydrogen deposition on the cathode at which time current flow and therefore corrosion will cease. The hydrogen plated-out on the cathode will not immediately bubble from it, thereby lowering the cathode potential and leaving room for more hydrogen, but will tend to remain in place to form a protective coating. Work is required to force this hydrogen from the cathode and the potential necessary to do this is known as the cathodic overvoltage of the metal. The overvoltage of hydrogen on steel is approximately 0.27 volts[1]. Fortunately, the normal potential differences causing corrosion of steel are lower than 0.27 v.; thus as the cathode approaches hydrogen polarization the corrosion reaction slows down until it reaches zero. It will remain zero until hydrogen either slowly bubbles away or is removed by reaction with oxygen in the soil.

The purpose of cathodic protection of steel pipe is to make the pipe potential equal over its entire area. Mears and Brown[2], working with a zinc-copper cell, have shown that complete protection is obtained when the potential of the cathode is brought to the potential of the anode by means of an external e.m.f. This is the goal of any cathodic protection system. Unfortunately, when working with steel pipes it is not possible to measure the values of the anode and cathode potentials on the pipe. It is impossible, therefore, to determine exactly the pipe potential required to give protection. The closest safe approximation for complete protection is to cover the entire pipe surface with hydrogen and keep it in that condition. Actually the only surfaces that need to be kept polarized are the cathodic areas for when this is done the cathodes have the same or greater potential than the anodes. Thus, if the pipe were half cathode and half anode, only half the surface area would need to be covered with hydrogen. Although the purpose and action of cathodic protection is thus well understood in general, many of its details are not well known.

[1] *Corrosion Causes and Prevention*, F. N. Speller, p. 21, McGraw-Hill Book Company, New York, New York, 1935.

[2] "A Theory of Cathodic Protection," by R. B. Mears and R. H. Brown, Transactions of the American Electrochemical Society, p. 519, 1938.

Interpretation of Pipe-to-Soil Potential Measurements

One of the common indexes used to determine whether a pipe is protected is the measurement of the pipe-to-soil potential. In making measurements of this type a saturated copper sulphate electrode is commonly used as the reference electrode and the difference in potential between this electrode and the pipe is measured using either a potentiometer or a high-resistance voltmeter. It is also a commonly accepted fact deduced from experience[3] that if the overall voltage reading of this system is 0.80 v. or above, the pipe is protected. It is of interest to examine the meaning of this value from the theoretical aspect and to examine closely the meaning of potential values in general in these systems.

Fig. 1 includes, in addition to the view of a normal corroding pipe, a cathodic protection system and a copper sulphate electrode and potentiometer for measuring the pipe potentials. The electrode is usually placed in the soil above the pipe or just to one side and contact is made to the pipe with a sharp-pointed metallic instrument. The potential difference is then read on the meter and the total reading recorded. This potential is the sum of the copper sulphate potential value and the pipe potential value.

The potential of the saturated copper sulphate electrode is easily calculated. The standard* single electrode potential, E_o, of the cell cu, Cu^{++}, is —0.344 v. The potential of the cell using a saturated copper sulphate solu-

[3] Unpublished paper presented at A.I.E.E. Symposium on Cathodic Protection, by V. L. Neely, Houston, Texas, 1939.

*Potential of the metal in solution containing metal ions at unit activity or 1 g.-mol per liter of effective metal-ion concentration.

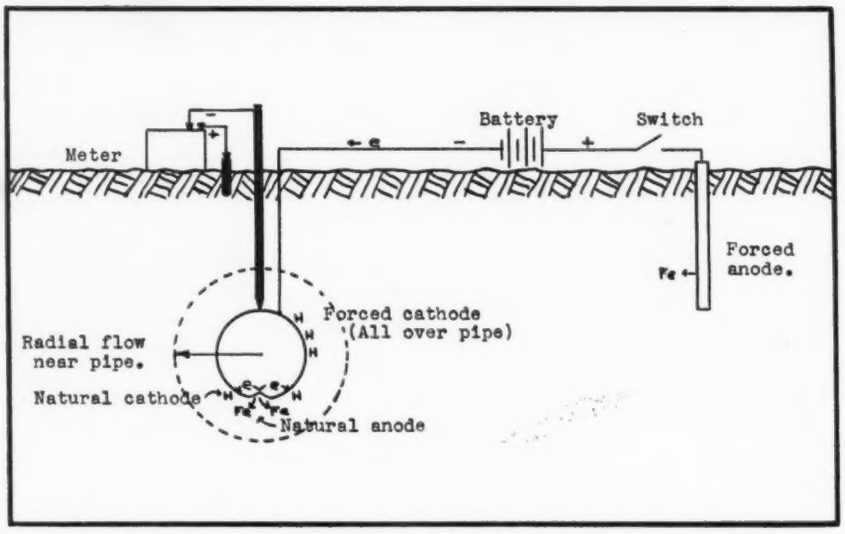

Fig. 1. Natural and forced electrical drainage conditions on pipe

tion may be calculated from the equation:

$$E = E_o - \frac{RT}{NF} \log aCu^{++} \quad . \; . \; (1)$$

where

a = activity of the copper ions in a saturated copper sulphate solution.

R = gas constant

T = temperature, °C. abs.

N = valence of metal

F = 1 faraday or 96,000 coulombs (abs.)

The solubility of copper sulphate at 25°C. is 18.5 g. per 100 g. of solution or 0.86 mols per liter. Using the published activity values for copper sulphate[4] and interpolating to 0.86 normal, a becomes 0.0330. Substituting this value in (1), the potential of the saturated copper sulphate electrode becomes —0.300 v. This potential is a fixed value for the temperature 25°C. It will change with temperature.

The question becomes, after the pipe-copper sulphate electrode reading is taken, what is the meaning of this reading? The reading is of course equal to:

$$E = E_{cu} + E_{fe} \quad . \; . \; . \; . \; . \; . \; . \; (2)$$

or, E is the sum of the copper sulphate electrode potential and the effective steel-pipe potential. The steel pipe may be subjected to a variety of conditions such as numerous cathodic and anodic areas, variable moisture conditions, soil gases, air, etc., and each of these contributes to a different potential. The pipe potential reading is then an average potential effect of all the different potentials and the relative areas over which they occur.

The pipe can act as one of at least three different kinds of single electrodes. These are: a ferrous electrode, a ferric electrode, and an oxygen electrode. The value of the potential reading depends upon which type of electrode the pipe represents. Also, the values for these three kinds of electrodes vary over wide ranges.

For a ferrous electrode the standard electrode potential, E_o, at 25°C. is 0.441 v. If the condition shown in Fig. 1 existed and the solution around the corrosion pit was saturated with ferrous hydroxide at a pH of 8 the potential of the iron at the pit could be calculated by the equation:

$$E = E_o - \frac{RT}{NF} \log a\, Fe^{++} \quad . \; . \; (3)$$

The solubility product of ferrous hydroxide in gram mols per liter is:

$$K = (Fe^{++}) \times (\overline{OH}) \times (\overline{OH}) = 1.64 \times 10^{-14}$$

The pH of 8 gives an $(\overline{OH})$ concentration of 1×10^{-6} g. mols per liter. The concentration of ferrous ions, Fe^{++}, then is $\frac{1.64 \times 10^{-14}}{(1 \times 10^{-6})^2}$

= 0.0164 g. mols per liter.

Assuming unit activity for all concentrations of iron ions the variation of the ferrous standard electrode potential can be calculated from equation (3). The values obtained are as follows:

Concentration of iron ions, also (a)	*Log a Fe++*	*$\frac{RT}{NF} \times$ log a Fe++*	*E (volts)*
1.0	0	0	0.441
0.1	—1.0	—0.029	0.470
0.01	—2.0	—0.058	0.499
0.001	—3.0	—0.087	0.528
0.0001	—4.0	—0.116	0.557

The potential of the ferrous electrode at a concentration of iron ions of 0.01 g.-mols per liter (slightly less than the saturation value) is 0.499 v. The potential reading between a copper sulphate electrode and the corroding pit then would be:

$$0.499 + 0.300 = 0.799 \text{ v.}$$

If the switch of the cathodic system in Fig. 1 is now closed and current allowed to flow from the forced anode to the pipe the natural cathodic areas on the pipe will first be coated with hydrogen because they are at a lower potential than the anodes. When the total pipe potential is brought to 0.799 v. the pipe is protected because the cathodic areas are at the same voltage as the anodic areas and corrosion ceases so long as this condition prevails. If additional current is allowed to flow by raising the forced anode voltage the ferrous ions will be plated-back on the iron. In order to reduce the ferrous ions to a concentration of 0.0001 g.-mols per liter the copper sulphate-pipe potential would be 0.557 + 0.300 = 0.857 v. If the soil moisture contains salts, contributing to a low resistance, more current will flow than can be accommodated by the iron ions in solution and hydrogen will plate-out on the natural anodic areas. When the pipe anodes and cathodes are covered with hydrogen then an additional voltage of 0.27, the hydrogen overvoltage, is manifest and the overall potential reading is: 0.557 + 0.27 + 0.300 = 1.127 v. This is, of course, without any IR drop between the electrodes.

For a ferric electrode the single electrode potential, $E_o = 0.045$ v. If the pit in Fig. 1 is acting as a ferric electrode and the solution contains an effective concentration of 10^{-4} g.-mols per liter of ferric ions the cell potential can be calculated by an equation similar to (1). Thus:

$$E = E_o - \frac{RT}{NF} \log a\, Fe^{+++} \text{ or,}$$

$$E = 0.045 - (0.019 \times -4.0) = 0.122 \text{ v.}$$

If the corrosion pit is a cell of this type then hydrogen will develop on on the pipe cathode when the cathodic protection system is started, until the

[4] *Thermodynamics*, by Lewis and Randall, p. 362, McGraw-Hill Book Company, New York, New York, 1923.

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TABLE 1

Pipe-copper sulphate electrode potentials in different soils

A Luling-Sour Lake (8-in. bare pipe) (potentials 100 ft. apart)	B Lucas-Orange (8-in. enamel-coated pipe) (potentials 500 ft. apart)	C Lucas-Olean (Three 8-in. uncoated pipes) (potentials 0.5 mi. apart)
Date—8-11-38	Date—8-25-38	Date—9-25-37
0.45	0.58	0.39
0.41	0.58	0.50
0.38	0.56	0.48
0.45	0.55	0.64
0.26	0.55	0.53
0.30	0.55	0.44
0.24	0.55	0.47
0.27	0.53	0.36
0.25	0.55	
0.23	0.54	
0.28	0.54	
0.31	0.54	
0.24	0.53	
0.25		
0.25		
0.20		
0.22		
0.23		
0.17		
0.21		
0.21		
0.17		
0.25		
0.32		
0.26		
0.30		

pipe potential is 0.122 v. or the reading to a copper sulphate electrode is $0.122 + 0.300 = 0.422$ v. This voltage reading will mean protection for a ferric electrode. If current is permitted to flow until the ferric anode is converted to a ferric cathode covered with hydrogen, the hydrogen overvoltage will be manifest and the reading to a copper sulphate electrode without soil IR drop will be $0.122 + 0.300 + 0.27 = 0.692$ v.

To act as an oxygen electrode, the pipe must be covered with oxygen in contact with a solution saturated with oxygen. For the condition when the solution is alkaline the standard electrode potential, $E_o = -0.393$ v. The potential between this electrode and a copper sulphate electrode is $0.300 - 0.393 = -0.093$ volts. Such an electrode cannot be polarized by hydrogen because the oxygen will react with the hydrogen to form water and when this is done the iron will revert to a ferric or a ferrous electrode.

From these considerations it is obvious that if steel pipes act as ferrous electrodes, the total normal measured potential to a copper sulphate electrode would be approximately 0.799 v., if a ferric electrode it would be about 0.422 v., and if an oxygen electrode it would be about —0.093 v. The data also show that very little voltage is required in a cathodic protection scheme to reverse the ions in solution and start deposition of hydrogen on the natural anodes.

It is of interest to examine the normal pipe potentials actually measured in the field to determine near which of these three types of electrodes the pipe actually acts. Table 1 shows the pipe-copper sulphate electrode potentials of several lines without any current on the pipes.

Examination of the data in Table 1 shows marked differences in the potentials of the three different pipe lines. Soil A is a dry, sandy soil that drains rapidly after rainfall. The soil was dry and hard on 8-11-38 when the potentials were taken. The potentials ranged from a low of 0.17 v. to a high of 0.45 v. The most commonly recorded potential is in the range of 0.20 to 0.26 v. The pipe in soil B is well coated and the soil is damp to wet most of the time. The pipe potentials are all quite similar with little variation. The values range from 0.53 to 0.58 v. The pipe in soil C is bare to poorly coated. The soil is damp to wet most of the time and is quite corrosive. The potentials range from 0.36 to 0.64 v., a considerable range and also a higher range than found in the dry, well-aerated soil A.

TABLE 2

Effect of seasonal variation on natural pipe potential

A. Sour Lake-Luling 8-in. test section

Distance from initial point, ft.	Potential on 8-11-38, (ground dry) volts	Potential on 1-20-39, (ground wet) volts	Change in potential, volts
0	0.45	0.43	—0.02
100	0.41	0.36	—0.05
200	0.38	0.38	zero
300	0.45	0.42	—0.03
400	0.26	0.32	0.06
500	0.30	0.38	0.08
600	0.24	0.33	0.09
700	0.27	0.33	0.06
800	0.25	0.34	0.09
900	0.23	0.33	0.10
1000	0.28	0.36	0.08
1100	0.31	0.36	0.05
1200	0.24	0.38	0.14
1300	0.25	0.49	0.24
1400	....	0.51	....
1500	0.25	0.36	0.11
1600	0.20	0.32	0.12
1700	0.22	0.35	0.13
1800	0.23	0.50	0.27
1900	0.17	0.29	0.12
2000	0.21	0.49	0.28
2100	0.21	0.33	0.12
2200	0.17	0.31	0.14
2300	0.25	0.35	0.10
2400	0.32	0.34	0.02
2500	0.26	0.40	0.14
2600	0.30	0.40	0.10
		Avg. potential change.....	0.12 v.

B. El Vista-Olean 10-in. looped section

Location, miles south	Potential on 5-11-39, volts	Potential on 9-25-37, volts	Potential change, volts
32.00	0.43	0.48	0.05
32.25	0.44	0.71	0.27
32.50	0.46	0.59	0.13
32.75	0.45	0.43	—0.02
33.37	0.36	0.36	zero
33.50	0.38	0.57	0.19
		Avg. potential change.....	0.11 v.

These illustrations are typical of pipe-copper sulphate electrode potentials. In general, it is found that pipes in dry, well-aerated soils have low potentials typical of the line A values; in tight, wet soils wide variations in potentials are encountered although they tend to center around 0.54 v. For well-coated lines regardless of the type of soil, the pipe-soil potentials are quite consistent and have little variation. These potentials center closely around 0.54 v. These data indicate that normal steel pipe tends to develop a potential to a copper sulphate electrode of approximately 0.54 v. This value would indicate that the pipe tends to act as a ferric electrode, although this is not necessarily so, as this potential might only be the resultant of a combination ferrous-oxygen electrode. It is evident for soils of type A that the air present around the pipe in these well-aerated soils tends to lower the pipe potential. The data only show that the pipe potentials developed under different conditions vary over wide ranges and the steel does not act consistently to conform solely with any one of the three types of electrodes considered from the theoretical standpoint. The steel does seem to act as a complex iron-gas electrode approaching, with increasing moisture content or pipe coating, a probable potential of 0.54 v. This does not mean that pipe at a potential of 0.54 v. is not in a corroding condition. On the contrary, many non-corrosive soils will show a pipe potential as low as 0.17 v. and potentials of 0.54 v. or higher are obtained in corrosive soils.

Seasonal and Current-Time Influences on Pipe Potential

A. Seasonal variation of pipe potential. The previous data have shown how pipe potentials vary for different soils and that in general, pipes in wet soils possess higher potentials than pipes in dry, well-aerated soils. From this it might be reasoned that the natural pipe potential would vary if its environment changed from that of a dry, well-aerated condition to one of a wetted soil. Extensive measurements have been made to determine how pipe potential measurements vary seasonally. In these cases no electrical drainage was being used. Table 2 lists this type of measurement for two groups of soils. Examination of the data shows that in Case A (the Sour Lake-Luling section), there was a decided increase in pipe potential when the soil environment changed from a relatively dry

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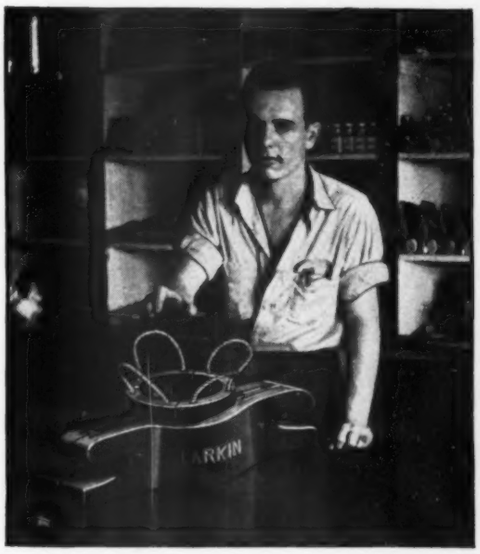

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TABLE 3

Luling-Sour Lake test section

Date	Current, amp.	Period current on	Average potential, volts (avg. of 26 readings)	Voltage increase with time, volts
4-11-38	zero	.....	0.356	.....
4-19-38	5.0	1 hr.	0.490	.....
4-27-38	5.0	18 days	0.514	0.024
5- 4-38	5.0	25 days	0.497	0.007
6-17-38	10.0	3 days	0.550	.....
6-23-38	10.0	9 days	0.559	0.009
6-28-38	15.0	5 days	0.636	.....
7-14-38	15.0	21 days	0.620	—0.016
7-27-38	15.0	34 days	0.647	0.011

condition in August to a wetter condition in January. The average increase in pipe potential was 0.12 v. and in individual cases this varied to as high as 0.27 v. The data for case B are less extensive but nevertheless show, over a four-month interval, pipe potential variations from zero to 0.27 v. and an average of 0.11 v. This average potential change of 0.11 — 0.12 v. might not seem to be of much importance but it is when bare pipe is to be protected. In case a pipe were brought by cathodic protection to a potential of 0.80 v. during the wet season and it was desired to keep it at this point, more current would be required to maintain this voltage when the potential dropped to 0.68 during the dry season.

B. Current-time influence on pipe potential. When cathodic protection is applied to a pipe it is frequently found that pipe-to-soil potentials increase with time. Considerable dependence is placed sometimes on this "build-up" reaching and maintaining such a value as to insure complete pipe protection. When making welding-machine tests to determine the amount of current necessary to bring a pipe to protection potential the current is applied for hours and sometimes for days to determine the maximum "build-up" and thus assure that the minimum amount of current will be used when the permanent drainage system is installed. It has already been shown how the natural pipe potentials vary 0.12 v. during the year and it is necessary to determine how the "build-up" voltage varies seasonally. In the average welding-machine test, it is usually considered that a voltage of 0.80 gives protection to a pipe and the amount of current necessary to develop this voltage is the amount used in the permanent installation.

Data have been obtained to determine the period of time required for the voltage "build-up" to reach its peak when a constant current is used. In one case a half-mile of test 8-in. bare pipe in a sandy, well-aerated soil was insulated from the other pipe in the line with insulating flanges. The original potentials were read and then a 5-amp. drainage was placed on the pipe. The new potentials were read immediately, after 7 days, and after 14 days. The current was later increased to 10 amp. and readings taken immediately, after 17 days, and after 24 days. The current was then increased to 15 amp. and read after 5 days, 22 days, and 35 days. The data are given in Table 3.

These data show for 5 amp. after 25 days a voltage "build-up" of only 0.007 v.; for 10 amp. after 9 days an increase of only 0.009 v. above the 3-day potential for this current; for 15 amp. after 34 days an increase of only 0.011 v. above the 5-day current value. For this pipe line at least, the voltage "build-up" is extremely slight. To show further this effect the test was made differently. The current was discontinued for several days and the potentials of 26 points or stations were measured; the current was then adjusted to 5.0 amp. and the potentials measured after 24 hr. This was then repeated for 10.0 amp.; 15.0 amp., and 19.5 amp. for similar periods. The average voltage increases obtained are given in Table 4.

TABLE 4

Voltage increase with current
Sour Lake-Luling test section

Current, amp.	Time, hr.	Change in potential, volts
zero	..	zero
5	24	0.111
10	24	0.208
15	24	0.328
19.5	24	0.394

These data show that for this pipe line the voltage change is directly proportional to the current and little or no "build-up" occurs.

TABLE 5

Seasonal variation of pipe potential with cathodic protection

Date	Rectifier output, amp.	Potential, volts	
		Three 10-in. pipes	10-in. loop
Lucas-El Vista section (milepost 32.00)			
9-25-37	zero	0.49	0.65
10-28-37	87	0.64	0.75
12- 1-37	87	1.0	1.0
3- 2-38	85	1.0	1.0
9- 1-38	90	0.76	0.77
11-23-38	90	0.78	0.80
Lucas-El Vista section (milepost 33.00)			
9-25-37	zero	0.38	0.38
10-27-37	70	0.65	0.86
12- 1-37	77	0.91	0.81
3 -2-38	77	0.76	0.95
9- 1-38	78	0.62	0.64
11-23-38	75	0.68	0.69

A second set of pipe lines to which cathodic protection had been applied was studied over a period of 12 months. Although more than 600 readings were made during this time only a few typical instances are given. The data in Table 5 show the pipe potentials for two parallel 10-in. pipes at constant current flow for a yearly period.

For these 10-in. pipes the potentials increased from values, which in 3 of the 4 cases were below 0.80 v. 24 hr. after the current was turned on, to potentials of 0.81 to 1.0 v. after 34 days. The potentials remained at these high values during the early part of March but when they were determined in September and November they had dropped below the desired potential of 0.80 v. The current flow to the pipes remained constant during the entire time. The explanation is twofold. The soil was relatively dry when the September and October, 1937, potentials were read. Before December the soils were well wetted and this change caused the pipe potential to shift upward at least an average of 0.12 v. Inasmuch as this well-wetted soil condition persisted from December to March, it resulted in the removal of air from around the pipe. This allowed the hydrogen plated-on the pipe to remain and develop its full effective overvoltage potential. From sometime after March 2 through November 11 the soils dried out and air gained access to the pipe, resulting in depolarization of hydrogen and the development of an iron-air cell having a subsequent voltage below 0.80. In this case it is obvious that an observer on a welding-machine test would have had to run the test from September 25 to about December 1 to develop the full "build-up." Thus it is apparent that no definite time for running a welding-machine test can be arbitrarily chosen if the full benefit of the hydrogen polarization is to be obtained. It is also equally evident that the use of pipe potentials to determine pipe protection can result in puzzling readings, difficult to interpret.

Acknowledgment

The writer wishes to thank the Executive Department of the Gulf Oil Corporation for permission to publish this article.

EDITOR'S NOTE: Another article on cathodic protection by the same writer will appear in an early issue.

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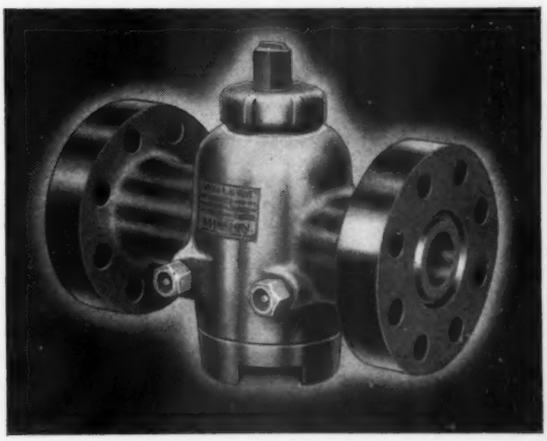

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Refining Lubricants by Solvent Extraction

The six more important processes are discussed briefly—principles of solvent extraction in general are outlined

By ARCH L. FOSTER

The Lubri-Zol Corporation, Cleveland, Ohio

THE application of selective solvents to lubricating oil refining is of comparatively recent development, the last decade having seen the greater part of the advances in this particular field. Solvent extraction was first applied on a large scale by Edeleanu to the refining of kerosine and burning oils, using liquefied sulphur dioxide. In the middle 1920's this solvent was applied in this country to the refining of lubricating oils, especially of premium turbine oils.

A photograph and biographical sketch of the writer can be found on page 33 of the August issue of *The Petroleum Engineer*.

The primary principle in solvent extraction is the selective solvent action of the treating agent on the different components of a lubricating oil fraction. The ideal selective solvent is a material that dissolves perfectly the undesirable constituents of a lubricant and rejects completely the desirable components. Such a solvent has not been discovered, but several materials have been found that approach more or less closely this ideal, and much of the improvement in modern lubricants is traceable to their use.

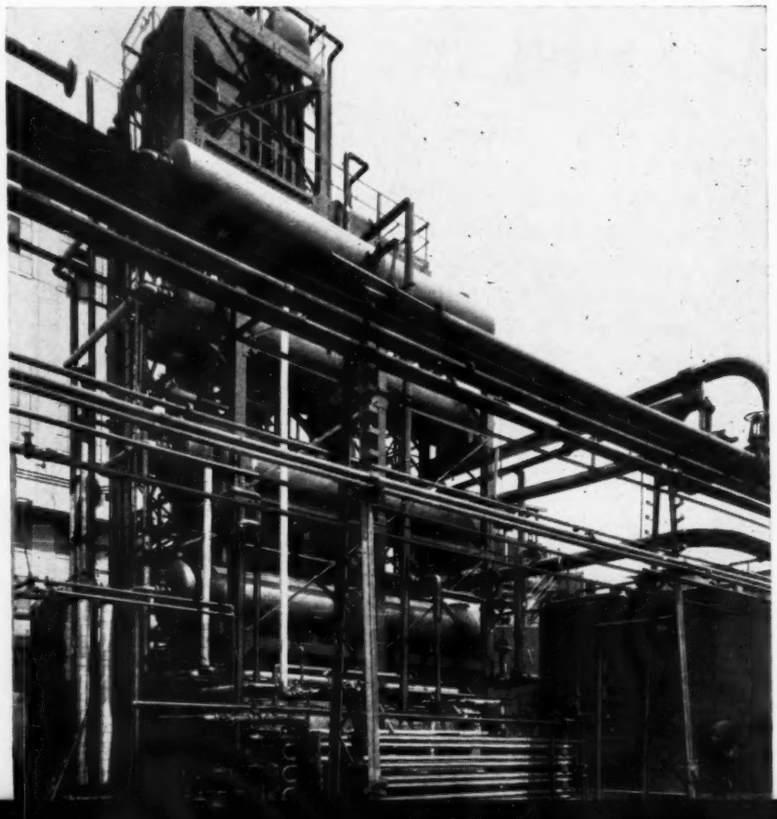
From the practical viewpoint, lubricating oil fractions of petroleum are composed of two types of hydrocarbons, forgetting for the time those "impurities" containing oxygen, sulphur, nitrogen attached to organic nuclei, or including these latter in the aromatic or undesirable types. These two main divisions of the lubricating fractions are the essentially paraffinic and the essentially aromatic types of hydrocarbons. Unfortunately these are by no means distinct and well-defined classes into which all hydrocarbons fall. If this were true the problem of the refiner in separating them by selective solvents would be relatively simple. As has been shown earlier[1], lubricating oils are found to contain, in addition to paraffin wax and the other elements mentioned, "paraffinic" hydrocarbons that are essentially naphthenes composed of saturated ring compounds possessing aliphatic side chains, unsaturated or olefinic groups, aromatic nuclei combined with each other and also combined with naphthenic and olefinic groups in a most complex mixture. Necessarily these various groups differ widely in their solubility in different solvents, a differentiation that is due to the innumerable combinations of these several groups that may occur. Actually the solubility of these products in any given solvent varies between complete solubility at practically any temperature to the extreme of insolubility at any temperature.

In the selection of a solvent for extracting lubricating oils, therefore, it is necessary to decide on the solvent that has the properties most needed in any given case to remove the materials least desired in the finished product, and that will at the same time retain maximum quantities of those constituents most needed in the finished lubricant. For example, as will be shown later, aromatic hydroxy compounds such as cresol show a strong selectivity for asphaltic and heavy aromatic bodies such as are found in mixed and naphthenic base fractions, especially residual oils from asphaltic, naphthenic, and mixed-base crudes. Chlorex, or dichlordiethylether, shows a high selectivity in separating the aromatic and the less paraffinic components of paraffin and mixed-base crudes from the large percentage of the more "paraffinic" naphthenes present in those crudes. Liquid sulphur dioxide shows a high selectivity for dissolving aromatic and olefinic compounds in the presence of aliphatic and naphthenic hydrocarbons, and for this reason is very successful in the refining of burning oils. But SO_2 has a low solvent *capacity* for these compounds, therefore, relatively large proportions of solvent to oil must be used to attain the required degree of refinement, especially in treating heavy oils.

The general principle of operation of a selective solvent treating unit is

[1] "The Technology of Refining Processes—Refining Methods for Lubricating Oil's," by Arch L. Foster, *The Petroleum Engineer*, July, 1940.

Chlorex plant. Countercurrent extraction tower not shown



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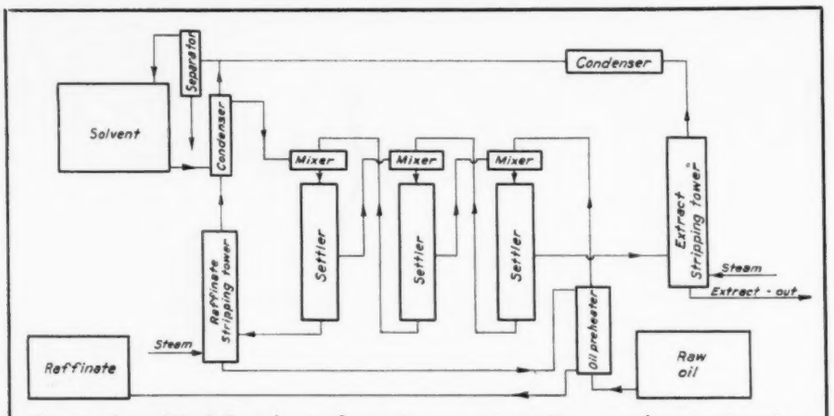

Fig. 1. Simplified flowchart of countercurrent continuous solvent extraction process. This chart is typical of most single-solvent processes

the same in every case, whatever the solvent may be. Oil and solvent are mixed at the required temperature by baffled or orifice mixers, proportioning pumps, or otherwise; the mix is allowed to settle and form two phases in tower or tank, and the two phases separated, each containing solvent to some extent. The extract or reject phase contains the greater portion of solvent, the raffinate, which is essentially insoluble in the solvent, containing only small amounts of solvent. One type of operation uses multiple contact systems, where solvent or raffinate phase flows countercurrent to the extract or insoluble phase, through several contact-settler steps. This principle effects more intimate contact between oil and solvent and more efficient separation of the two major types of hydrocarbons. More recently vertical baffled towers have been used, in which the heavier solvent enters at the top of the tower, the raw oil at the bottom, and the two phases pass countercurrent through the length of the tower, a procedure that has shown high extraction efficiency.

SO_2-Benzol Process

Sulphur dioxide, as stated, has a high selectivity for aromatic and other non-paraffinic hydrocarbons, but low solvent capacity. To increase the capacity and at the same time retain the selectivity of this solvent, benzol is combined with it, the combination showing excellent results in treating certain types of crude lubricating fractions, especially those from mixed-based and some naphthenic crudes.

Sulphur dioxide boils at 14°F. and, therefore, requires that pressure be maintained on the system to keep it in a liquid state. This of course is an advantage in recovery but requires operation at a high degree of efficiency in order to offset the deterioration to equipment resulting from the very corrosive character of the dioxide on metals, especially in the presence of water. Sulphur dioxide has been used in this country to separate the paraffinic components of light distillates from the olefinic and aromatic portions, in the preparation of industrial solvents where high paraffinicity or aromaticity may be desired. Technically, the refining of highly aromatic motor fuels can be accomplished efficiently in this manner because of the high selectivity of the dioxide for aromatics and olefins, but it has not been so employed to any appreciable extent.

In practice, the raw lubricating oil is frequently treated with SO_2 alone, after which the raffinate from this step is further treated with a benzol-SO_2 mixture to increase the degree of refinement. Results from a typical treatment by this procedure on a California dewaxed distillate is shown in Table 1, using first, 150 percent of SO_2 followed by a 70-30 mixture of SO_2 and benzol, by countercurrent extraction.

Here again the intermediate extract has proved efficient as a lubricant in industrial services where viscosity index is not a requirement, and where high temperature and oxidation stability are not necessary because of the mild temperatures encountered in service.

Chlorex Process

Chlorex is especially adaptable to extracting paraffinic crudes of the Pennsylvania and Mid-Continent types, and is applied to distillates of virtually all lubricating oil crudes. Its efficiency lies in part in its selectivity and production of high yields when the proportions of aromatic and non-paraffinic hydrocarbons are low and when the problem of exact separation of extract and raffinate is potentially serious.

An operation using a contact tower will be described as typical of the treatment of Pennsylvania residual and distillate stocks. This differs from the settler type of unit only in that the tower replaces the series of four horizontal settling tanks and mixers. Chlorex is pumped to the top of the tower in the ratio of about 0.6 to 1 when treating raw neutral stocks, at temperatures of 70° to 90°F., and the raw oil enters the bottom of the baffled tower. Raffinate solution is drawn from the tower bottom, and the extract passes from the top to a run-down tank. The Chlorex-oil interface level control is maintained at the top of the tower. Each phase is pumped to steam-heated vacuum towers, where the solvent is recovered from extract and raffinate. A typical operation resulted in a 93.5 percent yield of extracted oil. The charge had a 44.0 sec. viscosity at 210°F., a viscosity index of 96.3, and a viscosity-gravity constant of 0.815. The raffinate had a viscosity of 151.7 sec. at 100°F., 43.5 sec. at 210°F., a viscosity index of 103, and a viscosity-gravity constant of 0.809. The extract had an A.P.I. gravity of 15.7 deg., viscosity of 707 sec. at 100°F., and a viscosity index of minus 17. It is calculated that the 67-ft. ring-packed tower is the equivalent of eight settler-mixer units in extraction efficiency.

TABLE 2

Results of treating different base stocks with Chlorex in countercurrent extraction

Type of oil	Viscosity, Saybolt sec. at 210° F.	Percent solvent	Viscosity index		Carbon residue		Sludging time, hr.	
			Original	Raffinate	Original	Raffinate	Original	Raffinate
Mid-Continent	90	250	75	85	0.78	0.21	37	107
Pennsylvania	51	200	103	117	0.17	0.13	30	180
California mixed-base	59	600	54	95	0.64	0.27	10	83

TABLE 1

	Original oil	Second raffinate	SO_2 extract	Extract from mixed solvents
Gravity, deg. A.P.I.	18.0	28.0	6.0	21.0
Viscosity, S. U. S. at 210° F.	87	66	150	85
Viscosity index	0	90	....	30
Yield, percent	....	35	29	36

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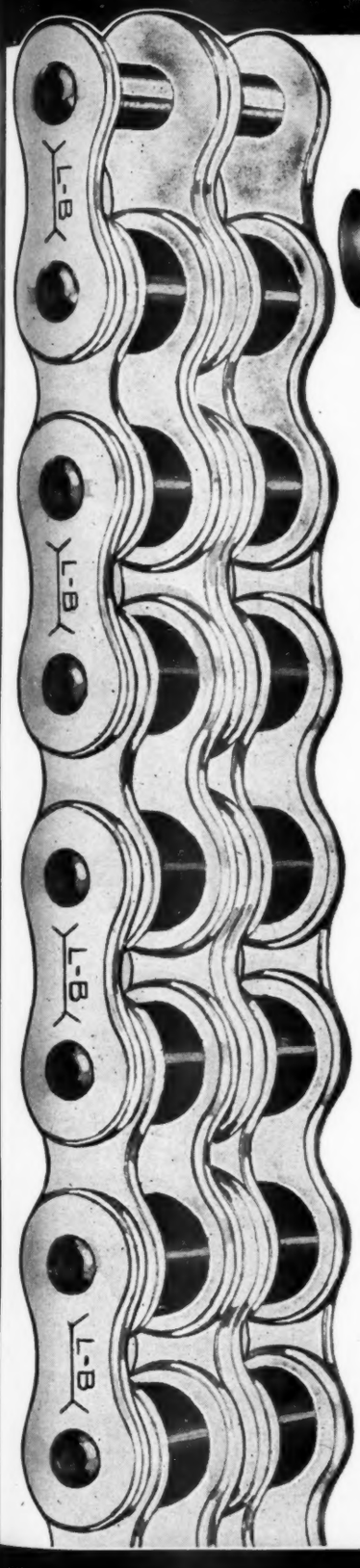

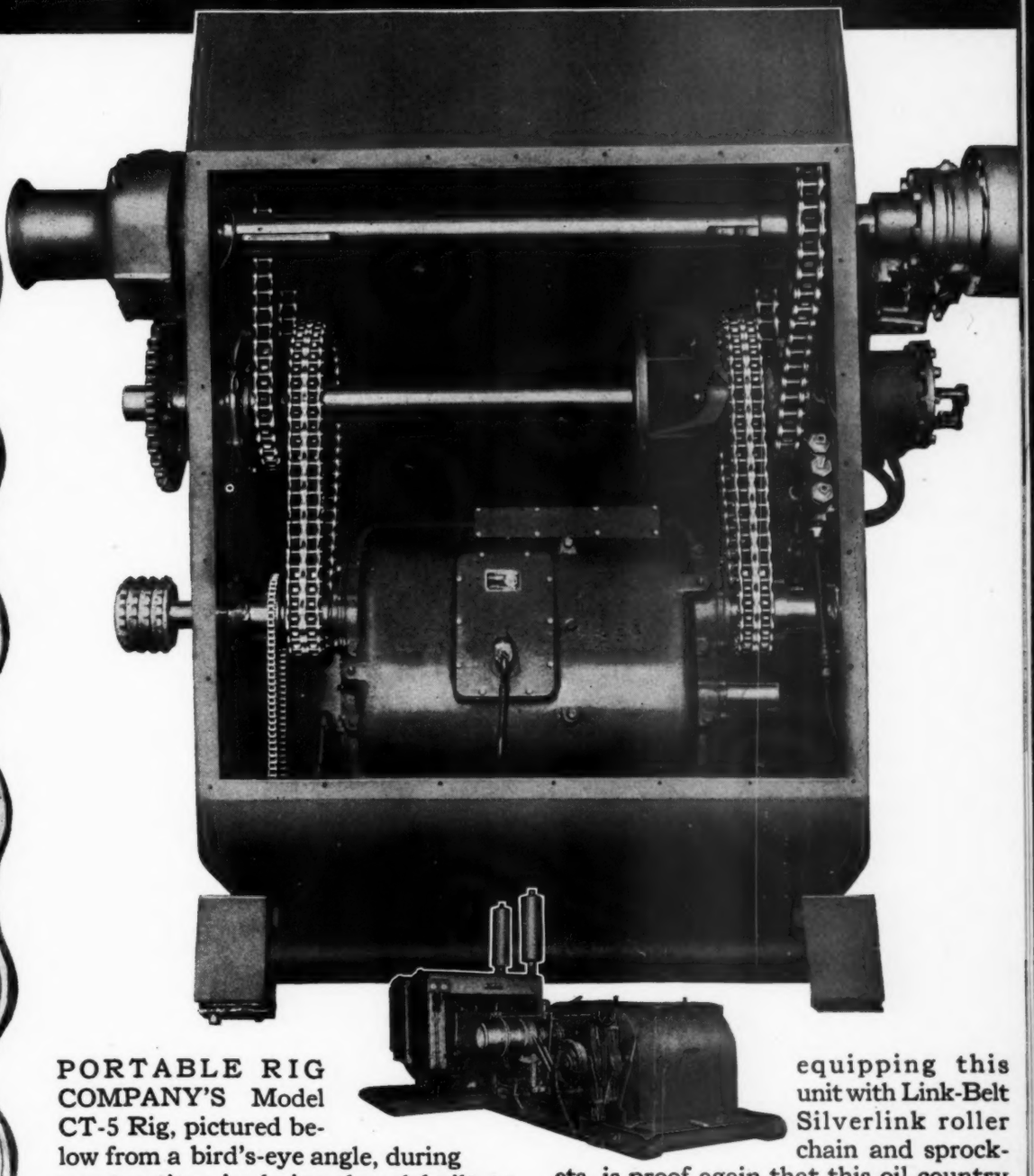

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Countercurrent extraction, as used in most of these plants, is far superior in yields, quality of product, and amount of solvent required to attain a given standard of improvement, over any type of batch extraction. To increase the viscosity index of a given Mid-Continent oil to 88, batch extraction required 3½-4 volumes of solvent (Chlorex); in countercurrent treating of the same oil only 1.4 volumes of solvent are required for the same results, operating at 75°F. From Mid-Continent stock having a relatively low viscosity index, a yield of 80 percent oil having a viscosity index of 82 was obtained, using 100 percent of solvent at 100°F. On the same oil using 200 percent of solvent at 50°F., 83 percent of 85 viscosity index oil was obtained. This indicates that the efficiency of extraction increases directly with the amount of solvent used and inversely with the temperature.

Table 2 illustrates the results that can be obtained on three different types of overhead stocks.

Chlorex has a boiling point of 352°F., specific gravity of 1.222, and specific heat of 0.369. It is miscible in all proportions with oil having a viscosity index of zero at temperatures between 40° and 80°F. Solubility of oil having a viscosity index of 100 in Chlorex is 1.1 percent between the same temperatures.

Nitrobenzene Process

Nitrobenzene, $C_6H_5NO_2$, shows especially high selectivity for naphthenic-aromatic constituents of lubricating oil and good solvent capacity. It is employed on both residual and overhead stocks, particularly the latter, either alone without further treating or more commonly in connection with acid treatment, a combination that shows good results. Reduction of the amount of filtration required is one of the advantages of the use of this solvent; according to investigators (*Proc. A.P.I.*, III, 1933, p. 63) nitrobenzene shows the highest selectivity for undesirable lubricating constituents of any solvent that had been tested at that time, which included several hundred chemicals. Nitrobenzene has a boiling point of 411.5°F., and vacuum and steam are required for economic recovery from the raffinate and extract. It is very stable under plant temperatures and conditions, and cycle loss is a small fraction of 1 percent of the quantity circulated.

In a typical nitrobenzene operation, oil and solvent are chilled separately to 50-60°F. or such temperature as may be predetermined and are passed countercurrently through three to five stages of settlers and mixers. A temperature of 350°F. is considered a safe maximum to employ in solvent recovery, and the recovery towers are operated at 30 millimeters of mercury pressure; steam is injected to strip the last traces of solvent from raffinate and extract. Heat exchange is used in cooling incoming oil with outflowing raffinate and extract solutions, and in preheating these in conjunction with the stripped oil before the solutions reach the recovery towers.

Table 3 gives the primary results obtained when treating various types of stocks with nitrobenzene.

Phenol Process

The use of chemically pure anhydrous phenol (carbolic acid), C_6H_5OH, was first developed on a commercial scale in Canada, in treating Mid-Continent, Colombian, and similar stocks. Phenol melts at 90°F., and boils at 360°F. Intermixed with petroleum oil, however, the melting-point is lowered so that the solvent remains liquid above about 85°F. It is necessary, therefore, in attaining optimum results to operate a phenol extraction process above this temperature. Raising the temperature of extraction increases the extraction efficiency of phenol and improves the quality of the finished product over that obtained at lower temperatures, but yields are necessarily and correspondingly lowered. Phenol appears to give excellent results in treating paraffinic stocks such as those of Pennsylvania and Mid-Continent origin, especially in reducing gravity and viscosity of residual oils and in improving the viscosity index.

Stocks may be treated either in batch or countercurrently with phenol, with the advantage, of course, lying with the countercurrent operation. Temperatures employed are varied from 100° to 180°F., the decision depending on the particular property that the operator desires to improve, whether maximum yield or maximum improvement is required. Temperatures as high as 250°F. may be used with special stocks. From 100 to 175 percent or more of solvent may be employed. Phenol is a definite hazard to workmen if spilled on the skin or if fumes are inhaled; however, the low vapor pressure of the material at operating temperatures combined with reasonable precautions have resulted in no greater actual hazards than those found with any commercial extraction solvent.

Table 4 shows the degree of improvement of various stocks treated with phenol at different temperatures and solvent percentages. Note that the degree of viscosity index improvement of the California distillate is especially high, although the yield is correspondingly low.

The Duo-Sol Process

The use of two solvents in the Duo-Sol process has proved peculiarly effective in the solvent extraction of residual oils, especially of those oils having comparatively small percentages of so-called paraffinic constituents and relatively large quantities of aromatic and asphaltic materials. To separate efficiently this small proportion of good lubricating material from a large amount of oil readily soluble in the extraction medium requires the maximum of selectivity in the solvent used. Cresol or the cresylic acids, (ortho-, meta-, and para-cresols), have a strong solvent action on non-paraffinic constituents, and a relatively high selectivity. To further increase the solubility characteristics of the two component groups, liquid propane is used as the other solvent. The cresols boil in the range 377-397°F., with specific gravities of 1.034 to 1.0465.

By thus adding a highly paraffinic solvent that has high selectivity for the paraffinic hydrocarbons, to a system containing a highly aromatic solvent with high solvent efficiency for the non-paraffinic materials, the "paraffinicity" and the "aromaticity" of these two phases are both increased. The aromatic-asphaltic products are less soluble in the propane-paraffinic phase than they are in the paraffinic fractions alone, and conversely, the propane solution of the paraffinic materials is less soluble in the aromatic solvent than is the paraffinic fraction itself.

Because of this increase in the characteristic properties of the two components, this process has been widely applied to refining non-paraffinic crudes throughout the world, plants operating on these solvents being probably more widely distributed than those using any other solvent. Al-

TABLE 3

Results of treating different stocks with nitrobenzene

Type of oil	Viscosity-gravity constant		Solvent, percent	Yield, percent
	Original oil	Raffinate		
Coastal District	0.874	0.810	100	28
Dewaxed Mid-Continent	0.845	0.805	150	52
West Texas residue	0.898	0.816	175	32

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TABLE 4

Results of treating various stocks with phenol

Type of oil	Phenol, percent	Temp., °F.	Viscosity, Saybolt sec. at 210° F.		Viscosity index		Gravity		Yield, percent
			Original	Raffinate	Original	Raffinate	Original	Raffinate	
California	125	90	69	59	—50	74	15.9	26.2	25
Coastal	100	115	64	60	22	74	20.0	25.8	65
Mid-Continent	150	140	144	111	71	103	19.8	25.8	68
Pennsylvania S. R. residue	125	250	230	223	102	113	24.7	28.1	55

though efficient in treating overhead stocks, the best results have been obtained with this process on residual stocks, ranging from Mid-Continent topped crudes to the highly asphaltic crudes from Mexico and the Orient. Percentage yields from these crudes are necessarily low. As the crudes are relatively cheap, however, and, especially abroad, first-class lubricating crudes are not generally available, and because the extract usually can be converted to gasoline of a fair to good grade by cracking, the matter of low yields is a disadvantage only because of the high throughput capacity of the unit required to yield a given quantity of finished product.

This process may be combined readily with other refining processes. Inasmuch as the raffinate is recovered in propane solution, it may be dewaxed, provided any appreciable amount of wax is present as in Mid-Continent and paraffinic California stocks, or it may be treated with acid advantageously because of the low viscosity of the solution and the resultant efficient settling of acid sludge. Filtration through clays is also facilitated by filtering in solution.

Cresol is used to the extent of three to four volumes (300-400 percent) per volume of oil. The amount of propane may exceed 200 percent or more, the percentage depending on the viscosity of the raw stock and the subsequent treatment that may be employed. Continuous countercurrent systems are used, usually in a horizontal, compartmented cylinder with the necessary mixing equipment. The fresh cresol enters at one end of this cylinder, the propane at the opposite end, and the raw oil is introduced at about the middle of the system. By this method the fresh propane washes the last of the paraffinic stock from the outgoing extract-cresol solution, and the incoming cresol removes the last traces of aromatic-asphaltic material from the outgoing propane-raffinate solution.

An indication of what may be accomplished in extracting mixed-base topped crudes with cresol and propane is given in Table 5.

Furfural Process

Furfural, or furfuraldehyde, is made by hydrolysis of oat and rice hulls, corn cobs, straw, etc., and has the formula $C_5H_4O_2$. Its boiling point is 323°F. and it has a specific gravity of 1.1622. Manufacturers of furfural state that it has exceptional stability in extraction service and in storage.

It is applied very successfully to either residuals or distillates with the advantage in favor of distillate treating. Extraction is usually carried out countercurrently in vertical baffled or packed towers, at 200-220°F. Solvent recovery employs vacuum and steam to facilitate stripping at low temperatures. Counter-flow operation shows, on one stock for example, a 12 viscosity index better improvement by countercurrent contact than in batch treatment, using 300 percent of solvent. For the same degree of improvement, countercurrent methods require the use of only about half the amount of solvent that batch treatment requires. The selectivity of this solvent is lowered as the temperature increases. The raw oil is introduced to the extraction tower at about 100°F., and the solvent enters at 225°F., for example. In this manner the solvent is cooled to a much lower temperature by the time it reaches the oil-entering end of the tower (tower top), and its highest selectivity is there, contacting the raw oil. The solvent is recovered at 230-250°F. under vacuum of 28 in. of mercury or higher, using open steam to strip the last traces from the oil.

Typical results obtained from a Mid-Continent distillate are as shown in Table 6, using 200 percent of solvent at 200°F. entering temperature.

Numerous other solvents have been experimented with in the intensive investigation that occupied the refining research laboratories several years ago. Among these may be mentioned aniline and crotonaldehyde. The latter is a pungent-smelling liquid of about 220°F. boiling point and specific gravity of 0.859. Because of its low boiling point it is easily removable from raffinate and extract alike at temperatures to 350°F. with steam and high vacuum. In treating Mid-Continent distillates, yields of 81 percent raffinate are reported, in which the viscosity index is increased from 66 to 96 or higher. In the system developed on an experimental scale with this solvent, a secondary raffinate was extracted from the stock, having a viscosity index of 20-50; or the extract might be divided between the primary and secondary raffinates in any chosen proportions. This secondary product is credited with excellent lubricating properties for purposes other than the high temperature, severe automotive engine service, and where oiliness is of importance. On Pennsylvania residual stocks the viscosity index can be increased from 96-97 to 107-108 with yields of as much as 90 percent.

A multiple contact system is devised for this process, wherein the mixed oil and solvent are separated by centrifuge, and the process repeated with fresh solvent until the desired degree of refinement is attained. The secondary raffinate may be obtained by similarly treating the first raffinate with larger quantities of solvent at different or the same temperature.

So brief a discussion of this very important subject on which such great amounts of money have been expended in research must be of necessity incomplete. The essential details have been given only in part, with enough of yields and results to indicate the flexibility of different solvents and the ability of several of them to improve to remarkable degrees the quality of modern lubricants.

TABLE 6

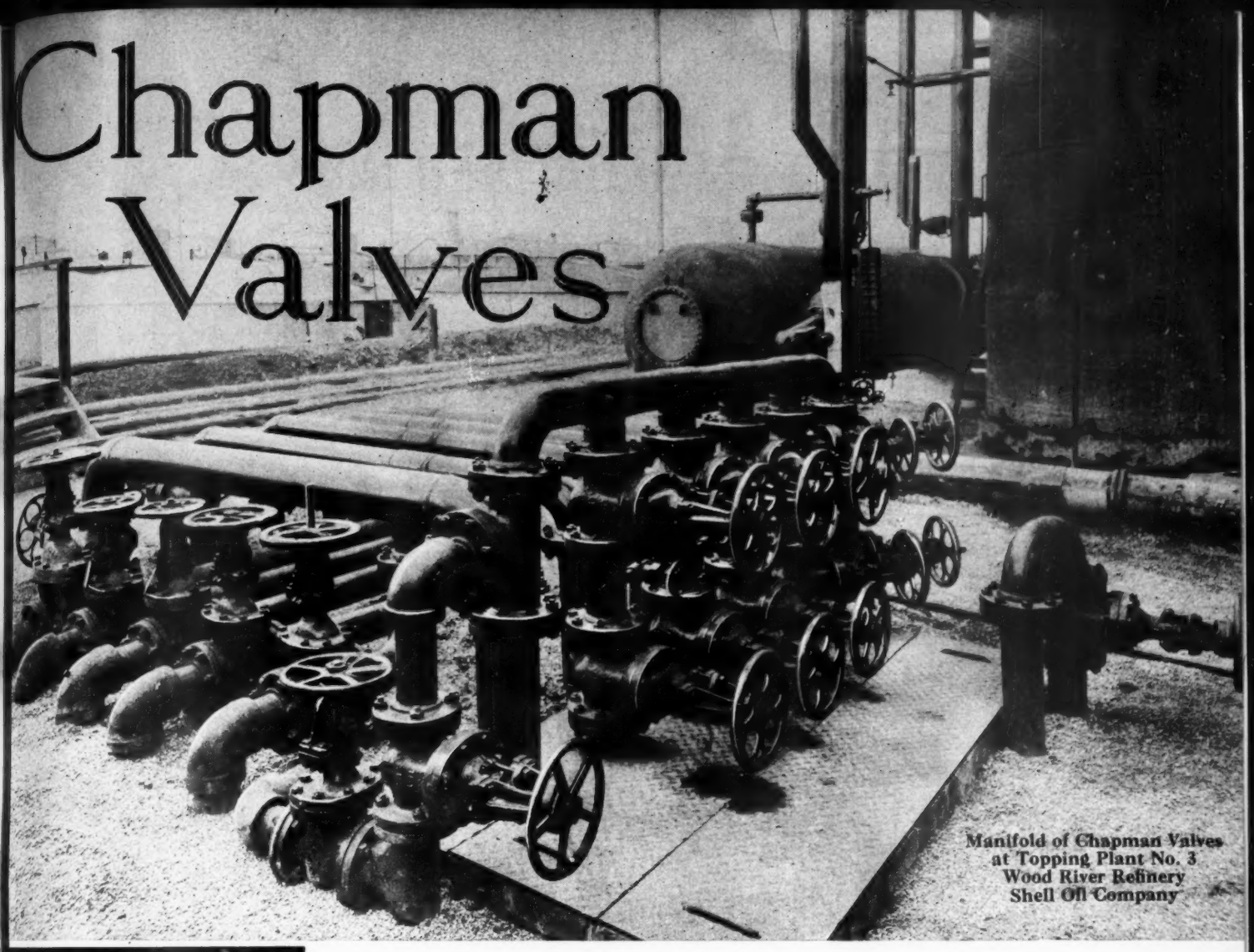
	Gravity, deg. A.P.I.	Viscosity, Saybolt sec. at 210° F.	Yield, percent	Viscosity index	Carbon residue	Sulphur, percent
Original oil	21.7	....	....	65	0.73	0.58
Raffinate	26.1	70	76	75	0.37	0.35
Extract	9.7	253	24	—127	....	....

TABLE 5

Typical results of extraction using cresol and propane

Type of oil	Gravity			Yield, percent	Viscosity index	Color, N.P.A.
	Original	Raffinate	Extract (sp. gr.)			
Oklahoma City crude	24.0	29.6	1.035	79.5	100	7
Ranger-Burbank crude	23.5	30.0	1.045	78.4	100	5½

Chapman Valves



Manifold of Chapman Valves at Topping Plant No. 3 Wood River Refinery Shell Oil Company

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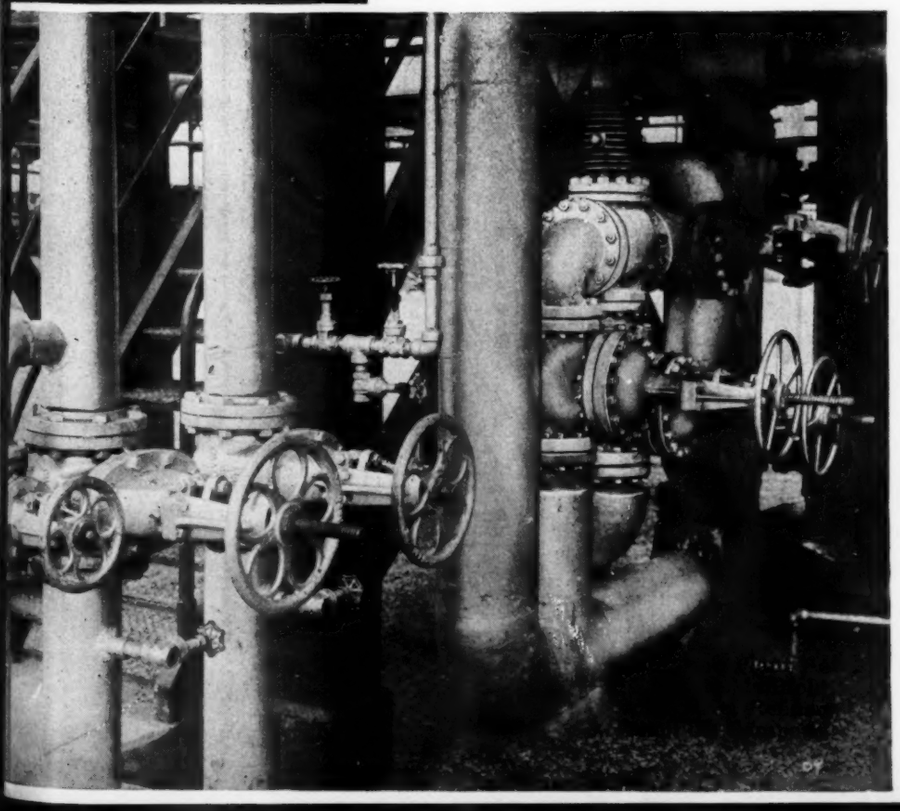

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INDIAN ORCHARD, MASS.

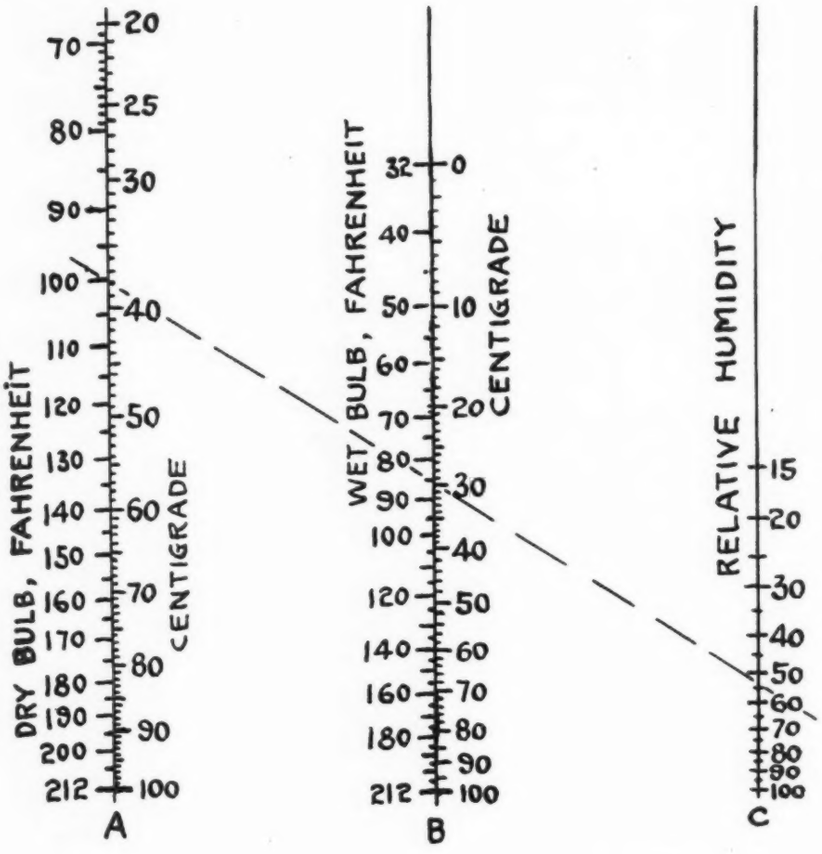
P 728.102.

Chart for Rapid Calculation of Relative Humidity

By
W. F. SCHAPHORST

HERE is a handy chart for quickly finding relative humidity. Tables and computations are unnecessary. Connect a straight line from the dry bulb temperature, column A, to the wet bulb temperature, column B, and the relative humidity is instantly given at the intersection with column C. Thus, if the dry bulb temperature is 100°F. and the wet bulb temperature, 85F°., the dotted line drawn across the chart shows that the relative humidity, column C, is 54 percent.

The chart is based on a special formula developed by the U. S. Bureau of Standards. The formula has been tested by the Bureau for dry bulb temperatures between 20° and 100°C. An important advantage of this chart lies in the fact that it gives temperatures in both Fahrenheit and Centigrade degrees.



P 615.322.1

Uneven Ditch Line No Obstacle in Laying Pipe

THE installation of the 6-in. diameter line pictured in the accompanying photograph is a typical example of the flexibility of the acetylene process of pipe welding when combined with wrinkle bending. When an erratic ditch line made it impossible to tie-in factory-fabricated bends originally planned for use in the line, the blowpipe was effectively used to heat the standard lengths of pipe, and by wrinkle bending, quickly make them conform to the contour of the trench.

The entire line, which is 1.6 miles long, consists of 50-ft. lengths of pipe having 3/16-in. wall thickness, all joined by acetylene welding. After all joints and bends had been tested with soapy water while the line was under air pressure of 50 lb. per sq. in., the line was treated with hot-dope, wrapped, and then buried in the trench.

Wrinkle bending was employed to make this 6-in. pipe conform to the contour of the trench

Production of Non-Corrosive Inert Gas By the Combustion of Fuel Gas

Recirculation of flue gas through the burners controls concentration of nitric oxide formed by combustion of natural gas in air.

By THOMAS S. BACON

Research Engineer, Lone Star Gas Company

IN recent years, inert gas has become increasingly important in many fields. It may be used, and is being used today, for a variety of different purposes. One tire manufacturer has found it useful in expanding inner tubes against the walls of the curing molds. The paint and varnish industry has recently found it to be of value in displacing air above paints and varnishes, thereby preventing the deterioration of the product that would otherwise result from oxidation, and the accompanying filming, change of color, and corrosion of equipment[1]. The gas industry and the petroleum industry have used it, rather spasmodically, to purge pipe lines and tanks of explosive vapors[2]. The oil industry has also used it in the past to repressure oil-producing formations. Several gas companies use inert gas to mix with fuel gas having undesirably high heating values that are not constant, but vary considerably, to reduce the heating values to the desired degree of uniformity.

The term "inert gas" as used in industry does not describe gas of definite chemical composition, but is a general term used to designate a gas that will not react with the materials with which it is in contact under the actual conditions of use. Hence, a gas might be "inert" when used for one particular purpose, but might be found to be very reactive when used for some other purpose.

[1]H. W. Smith, Jr., "Gas" *16* No. 3, pp. 24-26 (March, 1940).

[2]W. J. Huff, U. S. Bureau of Mines, R. I. 3337 (February, 1937).

The cost of the inert gas is, of course, an important factor in determining whether or not it can be used for any particular purpose. Because of its low cost, boiler stack gas has long been considered as a possible source of inert gas. Stack gas, being a waste product, has no real intrinsic value, but it does fulfill most of the requirements of a satisfactory inert gas. It is composed principally of inert nitrogen, and contains appreciable carbon dioxide, which is also an inert gas under most conditions of use. Boiler stack gas will normally contain some free oxygen, but this can easily be held within the desired limits in a gas-fired boiler by proper burner control. Stack gas from a coal-fired or oil-fired furnace will also contain sulphur dioxide, which is an acid anhydride that will become corrosive if brought in contact with water. But if "sweet" natural gas is used as the furnace fuel, no sulphur dioxide will be found in the stack gas, and at first glance it might appear that the stack gas from the gas-fired furnace would be non-corrosive. But practical experience has proved that such is not the case. The experience and discoveries of a major gas company have shown rather definitely why boiler stack gas is corrosive, and further have shown how the corrosiveness of such a gas may be economically and effectively eliminated.

THOMAS S. BACON

began his business career with the Hercules Powder Company, Wilmington, Delaware, in 1923 as research engineer—From 1929 to 1931 was research chemist for Arab Gasoline Company, Eastland, Texas—1931 to present research engineer with Lone Star Gas Company, Dallas, Texas—Received bachelor's degree from Swarthmore College and master's degree from Massachusetts Institute of Technology—Is member of American Chemical Society, A.I.M.E. and Sigma Xi.

The Lone Star Gas Company built a plant in 1924 for the production of 10,000,000 cu. ft. per day of inert gas to be used in process work. The inert gas produced in this plant was composed of a mixture of boiler stack gas and of gas engine exhaust gas. This mixture of gases was cooled and compressed through two stages of compression to approximately 300 lb. per sq. in. gauge pressure, which is the pressure required for use in this proc-

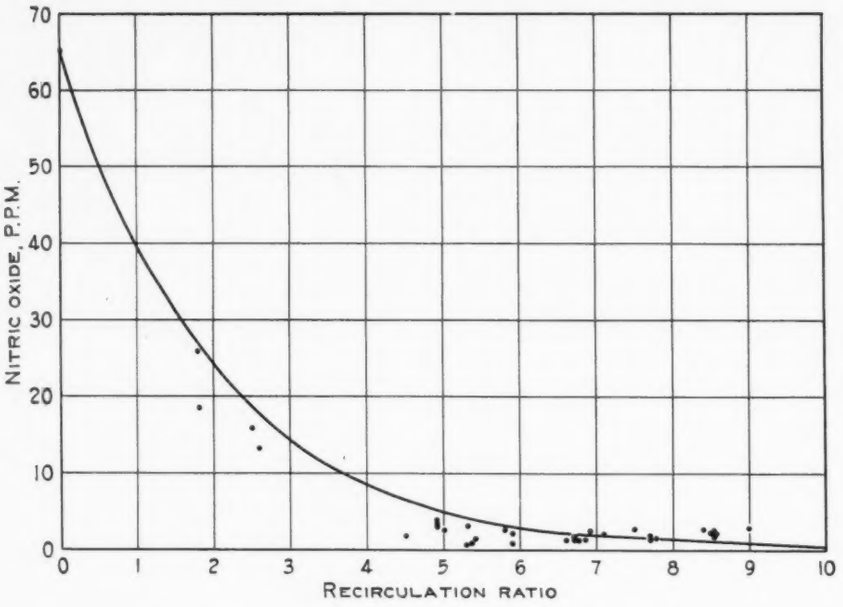


Fig. 1. Nitrogen fixation, experimental furnace

ess work. Extremely rapid corrosion of the high-pressure plant equipment occurred, even though the natural gas used for fuel was free of sulphur. Analyses of the products of corrosion showed nitric acid to be chiefly responsible for corrosion. Tests showed the engine exhaust gas contained much higher concentrations of oxides of nitrogen than the boiler stack gas. Accordingly, operation of the plant was changed to eliminate the use of engine exhaust gas. Even after this change, however, the rate of corrosion of the high-pressure equipment was excessive, and still was found to be caused by nitric acid.

This experience showed clearly that appreciable fixation of nitrogen will occur during the combustion of natural gas. The fuel gas did not contain nitrogen compounds, but the products of combustion contained fixed nitrogen in the form of nitric oxide. The nitric oxide formed during combustion is present in concentrations sufficiently low to prevent its being detected readily at atmosphere pressures. Nitric oxide itself is odorless, and is not corrosive to iron equipment even when liquid water is present. When the products of combustion are cooled and compressed, however, the rate of oxidation of nitric oxide in the gas to nitrogen dioxide is very materially increased due to the increase in partial pressures of the nitric oxide and oxygen in the gas mixture. The nitrogen dioxide formed in this way will react with liquid water to form nitric acid, which of course will corrode ferrous equipment rapidly.

The formation of oxides of nitrogen by the normal combustion of fuel gases has been confirmed by other investigators. A German scientist published a paper on the subject in 1914, that probably represents the first published recognition of this reaction.[3] A committee of British engineers thoroughly investigated the formation of nitric oxide that occurs in the operation of domestic gas appliances, and reported their findings in 1931.[4] Some information has recently been published in this country of work done on the quantitative determination of oxides of nitrogen in furnace atmospheres.[5] But practical information regarding the significance of the presence of oxides of nitrogen in boiler stack gas, and its corrosive effects, has not been available.

[3]E. Terres, Journal fur Gasbeleuchtung *26*, pp. 605-13 (1914) and *28*, pp. 700-706 (1914).

[4]"Twenty-eighth Report of the Joint Research Committee of the Institution and Leeds University." Publication No. 36 of the Institution of Gas Engineers, London, England.

[5]Liebhafsky & Winslow, Industrial & Engineering Chemistry, Ana. Ed. *11*, pp 189-190 (April 15, 1939).

Methods for the removal of the fixed nitrogen from the boiler stack gas were thoroughly investigated. Solutions that might be effective for the absorption of nitric oxide are oxidized rapidly when used in the presence of free oxygen. It was concluded, therefore, that nitric oxide could not be absorbed completely from the stack gas. Attempts were made to oxidize the nitric oxide to nitrogen peroxide, which could readily be removed from the gas by absorption. The rate of oxidation becomes very slow, however, when low concentrations of nitric oxide are present in the gas, even when the gas is under pressure. It was found that satisfactory completeness of removal of oxides of nitrogen could not be effected economically in this way. It is possible that electrical methods could be used to decrease the time of oxidation. Such methods would require very careful control, however, and were not investigated.

As methods for the removal of fixed nitrogen from the inert gas appeared to offer little promise of success, attention was turned to a study of methods for the prevention of the formation of nitric oxide in the firebox. The preliminary data indicated that normal average firebox temperatures approximated 2800°F. Maximum flame temperatures, however, probably reached 3400-3500°F.[6] Analyses of the stack gases leaving the boilers showed concentrations of nitric oxide of 50-100 parts per million in the stack gases. Approximate analyses of the engine exhaust gases indicated that the concentration of nitric oxide in these gases was from 300-800 parts per million.

At first glance, a concentration of 100 parts of nitric oxide per million parts of stack gas, or 0.01 percent by volume, appears insufficient to cause much trouble. A plant with a capacity of ten million cu. ft. per day of this inert gas, however, could produce enough nitric oxide to make more than 150 lb. of nitric acid per day, theoretically. If this nitric acid is allowed to act on processing equipment, it seems reasonable to believe that its corrosive effects will be noticeable.

[6]Jones, Lewis, Friauf, and Perrott, J.A.C.S. 53, No. 3, pp. 869-883.

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National Herringbone Reduction Gears

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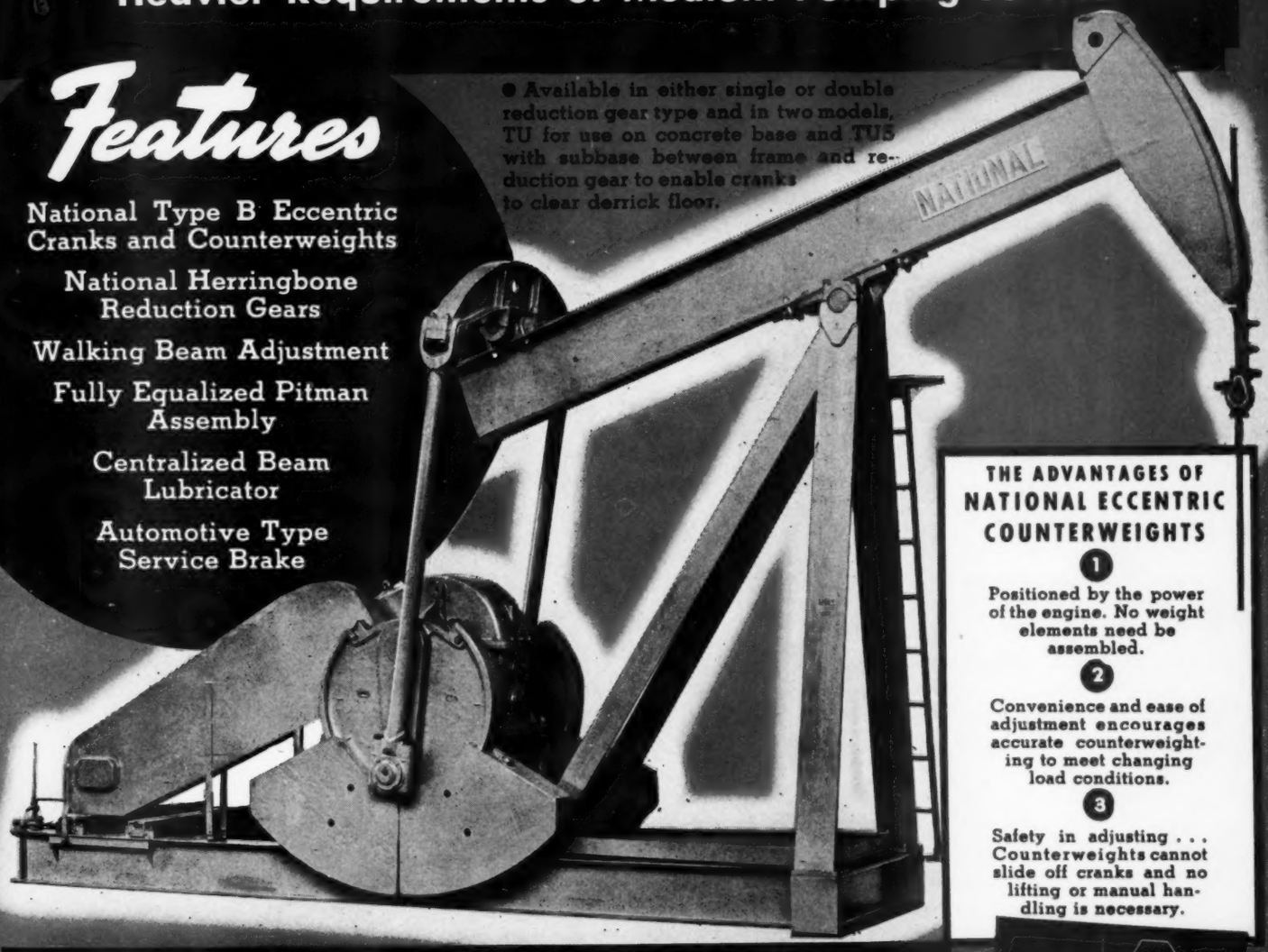

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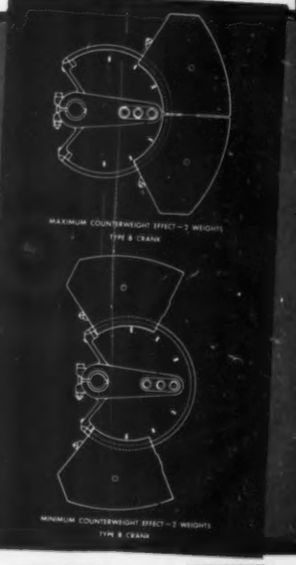
TYPES	TU464-HD46TB TUS464-HD46TB	TU464-H46TB TUS464-H46TB
API safe load of walking beam, lbs.	15,100	15,100
Polished rod strokes, inches	34, 44, 54	34, 44, 54
Maximum counterweight effect at max. polished rod stroke, lbs.	11,040	11,040
Over-all counterweight swing, maximum, inches	54	54
Reduction Gear:		
API peak torque rating at 20 spm., inch—lbs.	113,000	124,000
Over-all gear ratio	30.8	10.2
Crankshaft diameter at bearings, inches	5½	5½
V-belt sheave pitch diam., inches by number and section of belts	26 x 4C	29 x 7C
V-belt sheave pitch diameter, maximum, inches	32	29
Well end working centers	6'-9"	6'-9"
Height bottom of base to top of beam	12'-6¾"	12'-6¾"
Walking beam size and weight, CB section	18 x 70 lbs.	18 x 70 lbs.
Weights:		
Types TU with regular equipment, less extension base and counterweights, lbs.	10,364	10,674
Types TUS with regular equipment, less extension base and counterweights, lbs.	11,200	11,510
RM-35 crank counterweights, lbs.	1,625	1,625



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The fixation of nitrogen by heating air to high temperatures has been studied by Dr. C. P. Steinmetz.[7] This work is purely theoretical and is not supported by any published experimental work. As the thermodynamics appeared to be sound, however, this work was carefully considered in attempting to estimate the amount of nitrogen fixation at various flame temperatures. Steinmetz shows (Fig. 3) that a very appreciable concentation of nitric oxide will be formed if air is maintained at firebox temperatures for a considerable length of time. If this equilibrium curve alone is considered, therefore, the possibility of reducing nitrogen fixation to a reasonable amount by cooling the firebox does not appear to be promising. The curve showing the theoretical amount of nitric oxide present in air after heating for two seconds, however, shows a very rapid decrease in nitrogen fixation as the temperature decreases. This curve was calculated from formula 38 (by Steinmetz). The time required for gas to pass through the particular firebox under consideration at normal rates of firing was approximately 2 seconds. This curve should be indicative, therefore, of the results to be expected. The curve as drawn, however, does not take into account the changes in partial pressures of the oxygen and nitrogen that occur during combustion but is calculated for pure air. It should represent more nitric oxide, therefore, than would actually be produced under firebox conditions, as the average partial pressure of the oxygen in the firebox is less than that in air.

Firebox temperatures may be lowered materially when burning natural gas by returning some of the cooled products of combustion to the gas burner. Excessive recirculation of flue gas, however, will extinguish the flame. Preliminary calculations of combustible limits and flame temperatures indicated that flue gas recirculation would theoretically reduce the fixation of nitrogen in the firebox to less than 5 percent of the fixation obtained with a normal flame.

TABLE I.
Experimental plant operation

Test No.	Recirculated ratio	Observed firebox temperature, °C.	Excess air, percent	NO in stack gas, p.p.m.
3	0.0	1338	12	65.0
18	4.5	....	11	1.7
21	4.9	1193	12	3.0
22	4.9	1238	12	3.4
23	4.9	1252	10	3.7
2	5.0	....	0	2.6
25	5.3	1166	14	0.9
26	5.3	1160	13	0.9
27	5.3	1166	13	3.3
24	5.4	1160	16	1.3
13	5.8	1243	14	2.6
14	5.9	1238	12	2.1
19	5.9	....	14	0.9
20	6.7	1110	16	1.3
28	6.7	1116	13	1.3
29	6.7	1110	12	1.7
30	6.8	1127	13	1.3
12	6.9	1227	12	2.6
11	7.1	1243	10	2.1
1	7.5	....	8	2.6
4	7.5	1182	0	2.6
15	7.7	1093	12	1.3
16	7.7	1093	12	1.3
17	7.7	1093	12	1.3
6	8.4	1060	10	2.6
7	8.5	1154	11	2.1
8	8.5	1099	11	2.1
9	8.5	1038	10	2.1
10	8.5	977	9	2.1
5	9.0	1102	11	2.6
31-37	6.6	1050	12	1.3
38	2.6	1255	14	13.2
39	2.5	1271	15	15.8
40	1.8	1327	13	26.0
41	1.8	1327	12	18.5

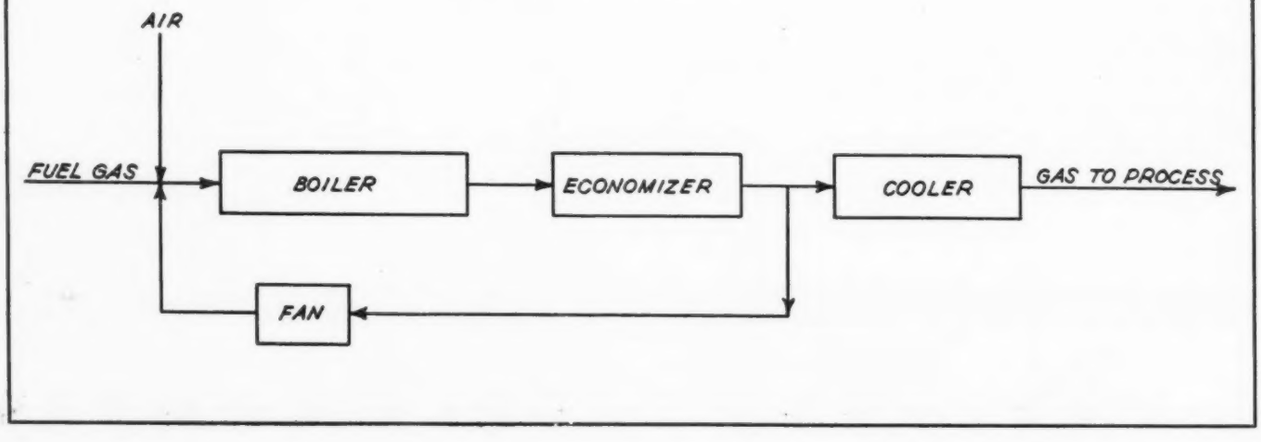
An experimental furnace was set up to check the above assumptions. The furnace was designed for an input of approximately 2,400,000 B.t.u. per hr. using as fuel natural gas having a heating value of approximately 1250 B.t.u. per cu. ft. The volumes of natural gas, primary air, secondary air, and recirculated products of combustion that were supplied to the furnace all were controlled independently, and were measured. The concentration of nitric oxide in the flue gas was determined by the method of Piccard, Peterson, and Bitting.[8] Furnace temperatures were observed with an ordinary thermocouple. This thermocouple gave comparative values of furnace temperatures only. The occasional use of a high-velocity thermocouple indicated that the observed temperature values were from 300 to 400°F. lower than the actual gas temperatures in the firebox. The results of this work are shown in Table 1. The firebox temperature was governed by controlling the amount of flue gas recirculated per unit volume of natural gas entering the burner. The recirculated flue gas was cooled to 140°F. and was mixed with the natural gas fuel before being returned to the burner. A flow sheet of the plant is shown in Fig. 2.

The experimental results, as shown

[7] C. P. Steinmetz, Chem. & Met. Engr. 22, No. 7, pp. 299-304; No. 8, pp. 353-357; No. 9, pp. 411-416; No. 10, pp. 455-462.

[8] Piccard, Peterson & Bitting, Ind. & Eng. Chem. Ana. Ed. 2, No. 3, p. 294 (July, 1930).

Fig. 2. Flow sheet for inert gas production



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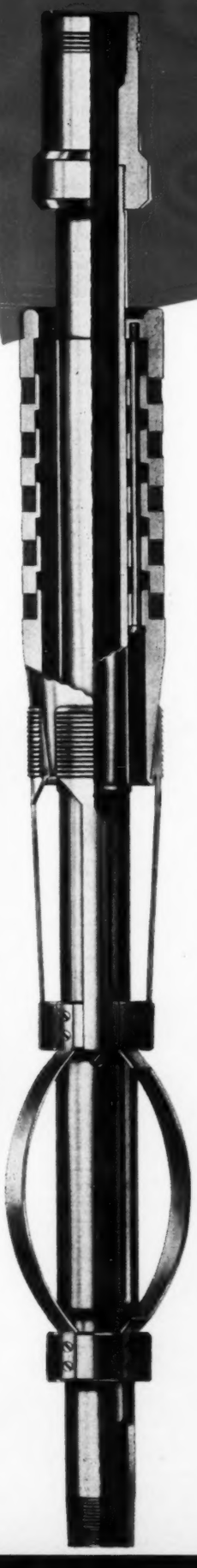

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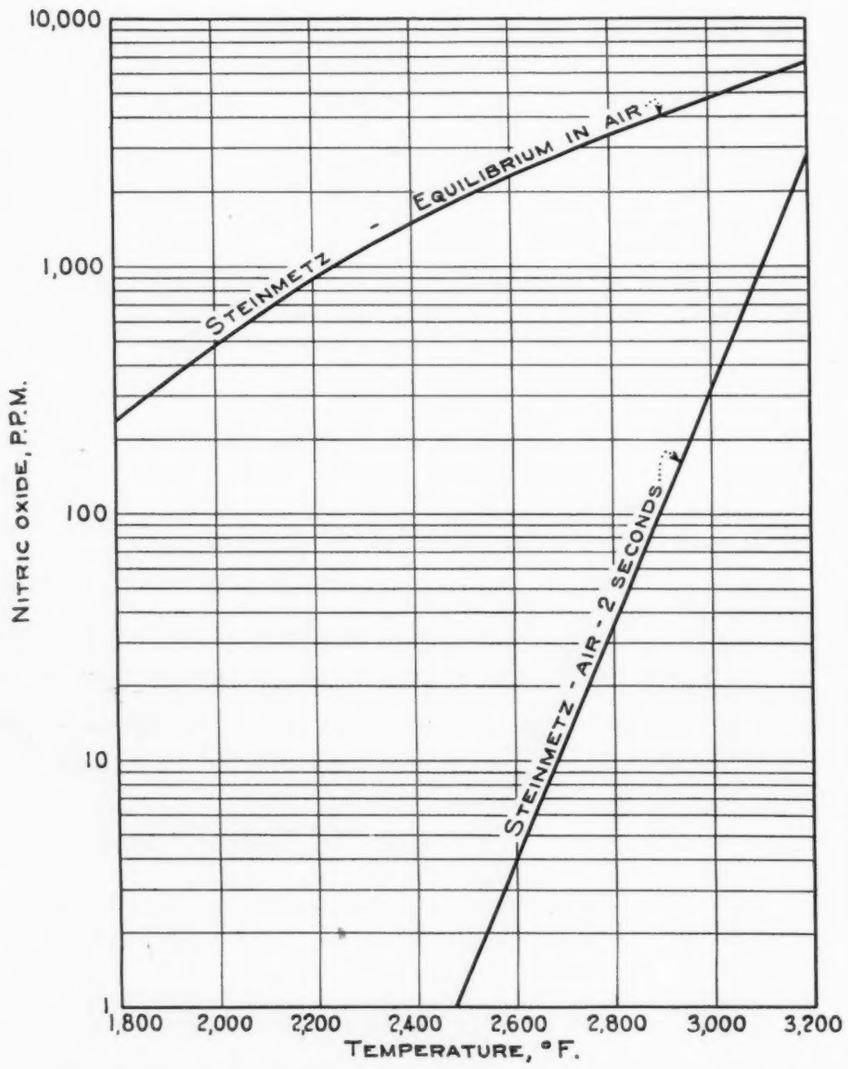
in Table 1 and Fig. 1, show a very rapid decrease in nitrogen fixation with increase in the amount of flue gas recirculated through the burners. It is evident from these data that recirculation of flue gas may be used to control the concentration of nitric oxide in the flue gas obtained by the combustion of natural gas in air, and that this concentration may be maintained at less than 3 parts per million by employing recirculation ratios of more than 6 volumes of flue gas per volume of natural gas fuel.

The recirculation ratios as reported are for total flue gas recirculated, and are not corrected for the volume of excess air present in the flue gas as recirculated.

The experimental data have been confirmed by observations of commercial plant operation. Oxides of nitrogen were determined in the plant discharge gas by the Piccard, Peterson, and Bitting method used in the experimental work, and also by the use of a nitric oxide recorder made by the United Gas Improvement Company of Philadelphia.[9] Agreement between the two methods of analysis was found to be good. The nitric oxide recorder as supplied by the manufacturer subjected the gas samples to a caustic wash for the removal of nitrogen dioxide before analysis. In actual practice, the caustic wash was eliminated so that the analysis of the gas as obtained included fixed nitrogen combined as nitric oxide and also as nitrogen dioxide.

[9]W. E. Stackhouse, "Instruments" 9, No. 6, pp. 161-163.

Fig. 3. Nitrogen fixation



Data on plant operation, covering a period of several months, showed an average nitric oxide concentration in the plant discharge gas of 1.2 parts per million with concentrations varying from 0.6 to 3.0 parts per million. The recirculation ratio used in the plant was 7.5 volumes of flue gas per 1.0 volume of fuel gas. Excess air was carried at 10-20 percent.

The plant boilers were fired with less air than that required for complete combustion for a period of about two months. This caused the nitric oxide concentration in the boiler stack gas to decrease to an average of 0.5 parts per million as shown by the nitric oxide recorder. The recirculation ratio was maintained at 7½ to 1 during this period.

This inert gas plant has been in continuous operation since 1924. Corrosion of plant equipment, particularly corrosion of the high-pressure portion of the plant, presented a serious operating problem during the first 10 years of plant operation. The flue gas recirculation system was put into operation in this plant early in 1934, and corrosion has been entirely eliminated since that time. The same patented process[10] has been applied to other plants producing large volumes of inert gas, with entire success, and is now available, as a thoroughly proved commercial process, to anyone requiring this type of inert gas.

The overall costs of operating a boiler equipped to produce a non-corrosive stack gas are almost equivalent to the operating costs of a normal boiler. Some additional expense is incurred in the original installation for the recirculating ducts, fan, and meter. Also, the special burners required are larger and more expensive than the ordinary natural gas burners. This additional installation expense is largely offset, however, by the decreased maintenance on the firebox refractories, which is brought about by the low operating temperature of the firebox. The boiler efficiency is not measurably affected, as the heat removed from the boiler stack by the inert gas is returned to the boiler firebox.

[10]U. S. Patent No. 2,051,125, August 18, 1936.

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Gasoline Plant Converted to Combination Refinery-Natural Gasoline Plant

Six products now manufactured at Jefferson, Texas, plant as a result of series of expansions and enlargements

By A. J. MacKINNON, Plant Superintendent
and
DON ATTAWAY, Arkansas Fuel Oil Company

IN March, 1939, an article appeared in *The Petroleum Engineer* covering the erection of a gasoline plant at Jefferson, Texas.[1] The plant at that time consisted of the usual high- and low-pressure distillation systems, and a stabilizer unit. A rerun unit was also erected for the processing of absorption oil. In the months following, however, a series of expanions and enlargements have converted this plant into one of the most diversified installations of its type.

Late in 1939 it became apparent that the decline in bottom-hole pressures in the Gloyd horizon of the Jefferson area in Marion County, Texas, would make it necessary for the Arkansas Fuel Oil Company to make changes in its field gathering line pressures in order to maintain gas volumes and gasoline yields.

The plant at that time was treating about 11,000,000 cu. ft. of gas per day with its low-pressure system at about 46-lb. pressure and obtaining a yield of approximately 372 gal. per million cu. ft.; however, the gas volume was declining daily and a comparison of aggregate bottom-hole pressures for the months of December, 1939, and May, 1940, showed a decline of 44,074 lb. In December, 1939, the field allowable was 11,159 bbl. per day with an aggregate bottom-hole pressure of 264,604 lb. against an allowable in May, 1940, of 8,722 bbl. per day with a total bottom-hole pressure of 220,530 lb.

After a complete survey was made, several field gathering lines were enlarged and three gas compressors purchased. A system of 51 leases containing 89 wells was tied-in and the field pressures declined from 46 lb. to almost atmosphere by the installation of these three 400-hp. angle-type gas engine compressors.

These engines have four cylinders on the power end, each 14 in. by 14 in., with compressor cylinders 23½ in. by 14 in. Such an installation has a capacity of 15,000,000 cu. ft. per day when operating at 300 r.p.m. and taking suction at zero lb. and discharging at 40 lb.

Each engine is equipped with an individual water circulating pump arranged to insure definite water circulation at each unit in proportion to the speed at which the unit operates. Likewise, the engines are fitted with water-cooled exhaust manifolds and maxim silencer mufflers.

Safety equipment consists of a mercoid switch on outlet water and lubricating oil pressure. In event of water or oil failure, the engine is automatically shut down. Each flywheel is equipped with an overspeed trip mechanism that grounds the magnetos.

In conjunction with the compressor installations, an induced-draft cooling tower 24 ft. high, 19 ft. wide, and 22 ft. long was erected. Four gas coolers having 60 tubes each are situated in the base of the tower to produce a temperature drop in the gas from 225°F. to 90°F.

Water for the system is obtained from water wells in the plant yard and a 1600-bbl. cypress tank serves as a reservoir for make up. Water over the cooling system of engine and compressor jackets is handled by a 750 gal. per. min. turbine-driven centrifugal pump. A standby of like make and capacity is also installed.

[1] "Absorption-Type Plants Extract Gasoline from Gas Produced in Rodessa Field," by W. F. Floyd and Frank H. Love, *The Petroleum Engineer*, March, 1939.

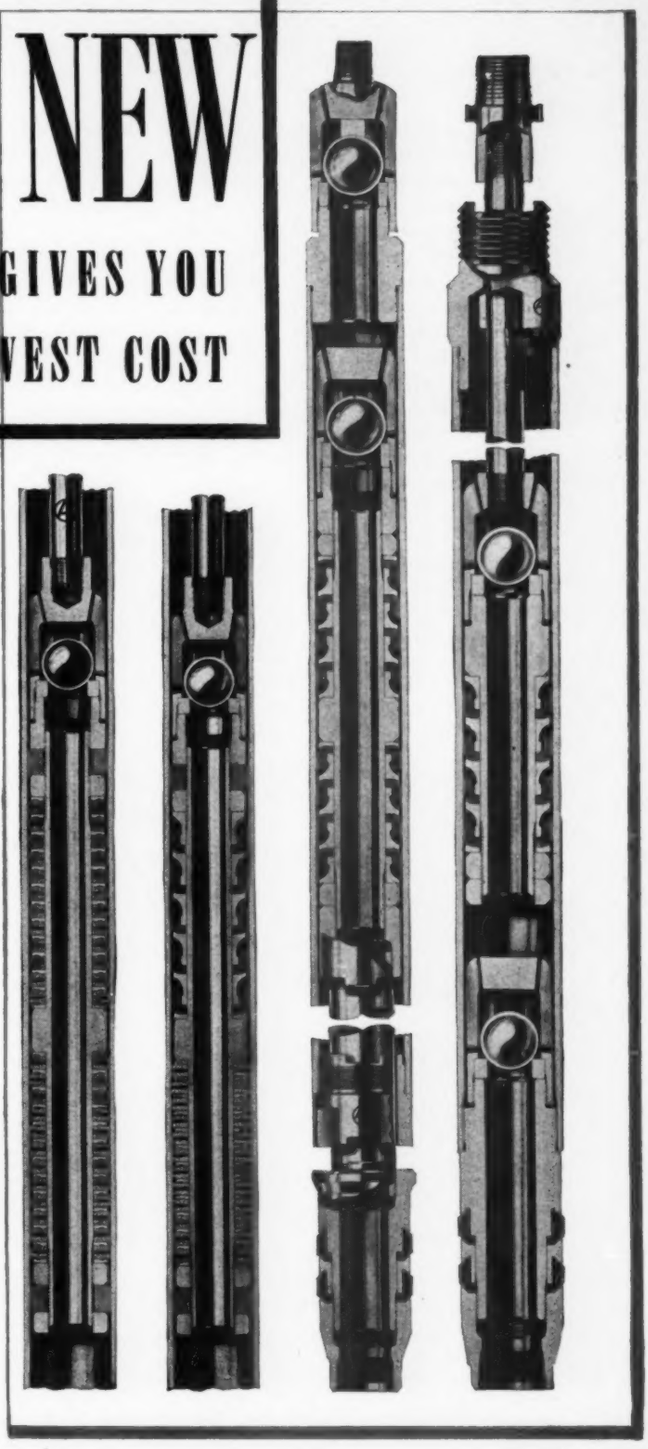
A. J. MacKINNON

is a native of Nova Scotia, Canada, and his early experience in steam engineering and power plant operation was gained in Alberta—From 1917 to 1922 he was with Koppers Company of Pittsburgh, Pennsylvania, as mechanical superintendent of construction and operation of by-product coke plants—For 11 years he was superintendent of gasoline plants for the United Carbon Company of Monroe, Louisiana, and since 1936 has been with Arkansas Fuel Oil Company as plant superintendent—Is now at Jefferson, Texas.

DON ATTAWAY

began his career with the Dixie Gulf Gas Company as timekeeper in the Waskom district, January, 1923—Entered the payroll department of United Gas Company late in 1929 and worked there until he accepted a position with Arkansas Fuel Oil Company in September, 1930, in the gas accounting department—Worked successively as meter man, loading rack man, and utility man in the East Texas natural gasoline plant—Took an active part in the construction and operation of gasoline plants for the company.

THIS NEW AXELSON KUP-PAK PUMP GIVES YOU QUALITY PERFORMANCE AT LOWEST COST



Axelson Kup-Pak Pumps are designed and built to give quality pump performance at lowest equipment cost in those fields where production is restricted or does not warrant the use of other type or metal-to-metal pumps. Accurately molded cups are positioned on the plunger to operate in the cold-drawn, seamless steel barrel which is actually honed in a special honing machine. Made in both stationary and traveling barrel types in all standard lengths and diameters, the plunger construction can be altered to combine cups and neoprene rings, or to use neoprene rings only. They can be installed in the top of an old barrel or with a seating nipple in the well.

Axelson Kup-Pak Pumps are ideally suited for wells in which production can be handled with packing or cup plungers. Write for Bulletin on Kup-Pak Pumps.

Axelson builds three complete lines of Deep Well Plunger Pumps—Standard Liner Pumps (T. S. L. & R. S. L.), Sure-Seal Pumps, Kup-Pak Pumps—to meet every pumping condition and price requirement.

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SELLS AND *SERVICES*
OIL WELL PLUNGER PUMPS
AND SUCKER RODS . . .

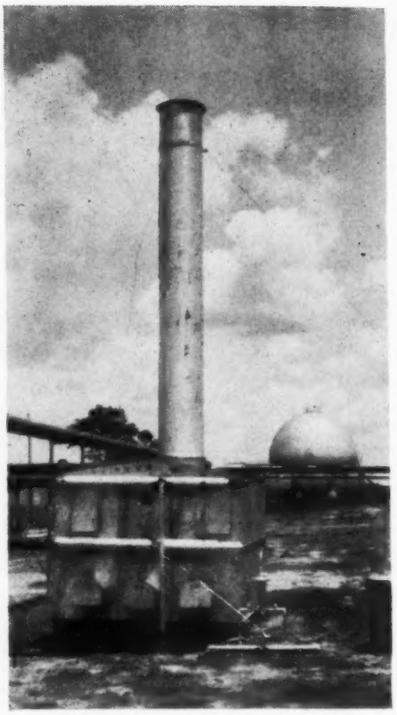
The gas from the compressors, after being cooled, is processed in a 7-ft. by 44-ft. countercurrent, conventional-type absorber.

Primary results of the plant extension showed an increase of about 30 percent in gasoline yield and the gas volume increased from 11,000,000 cu. ft. per day to about 14,000,000 cu. ft. Gasoline yield increased as was expected and in some cases a recovery of as much as 900 gal. per million cu. ft. was obtained.

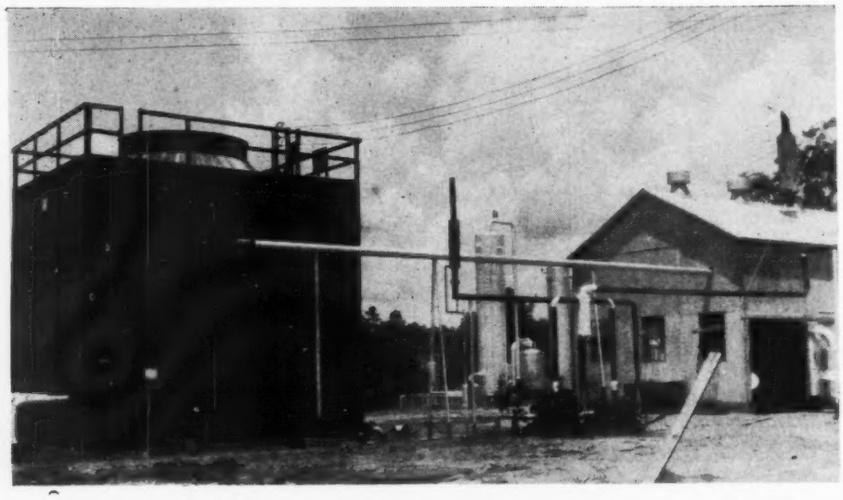
The increase in oil circulation, however, placed such a load on plant capacity that a revamping of the entire plant was necessary and consequently several preheaters and coolers were added as well as a 24-ft. extension put on the aerator cooling tower.

Recent completion of gas-distillate wells in the area required the plant to operate two high-pressure absorption systems. Four of these wells are tied into a separate absorption system that operates at 500-lb. pressure, the residue gas from which is used for repressuring. Gas from 8 other wells is gathered at 400-lb. pressure and after being processed is delivered to the company's distribution system.

These 12 wells produce varying amounts of condensate and this is trapped from the inlet scrubbers and separators to a storage tank in the plant yard. From here the raw condensate is pumped through a 40-tube, direct-fired oil heater, recently installed, and charged to a fractionating column where a 300°F. end point gasoline is obtained from the overhead stream. After this intial stripping, the oil is then charged through an upright-coil, direct-fired heater and the temperature raised to 460°F. for charging to a 24-in. by 45-ft. fractionating column where naphtha is recovered on the overhead stream and a side cut of water white absorption oil obtained.

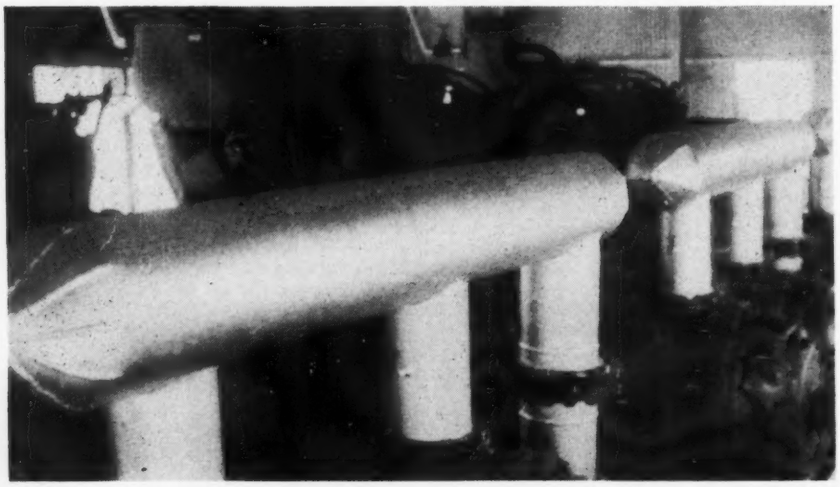


A 160-tube, direct-fired oil heater



Above—Induced-draft cooling tower at left, engine room at right, and water-circulating pumps in center

Below—Header arrangement on the 400-hp. gas engine compressors



The bottoms from this column are recovered and marketed as fuel oil, thus a complete recovery of the processed condensate is obtained and four different products produced.

The cycle of the enriched absorption oil was also altered to coincide with the condensate process system, and at present the rich oil from the absorbers is trapped into the usual vent tank, thence through heat exchangers and preheaters to the still where a 260°F. end point gasoline is recovered. This stripped oil is then moved by still pressure of 40 lb. through a 160-tube, direct-fired oil heater where the temperature is raised to 360°F. The oil is then charged to a flash tower of the naphtha still where the overhead is collected as naphtha and the denuded oil utilized as absorption oil.

Consequently a year of expansion and addition, culminated by the recent low-pressure conversion, has developed this plant from a straight casinghead gasoline plant into a combination refinery and natural gasoline plant. Currently a total of six different products are produced and shipped from this plant. Two grades of natural gasoline, a third grade motor fuel, naphtha, absorption oil, and fuel oil constitute the production. With this diversified production it was necessary to extend the loading rack to a seven car capacity and install separate loading lines to transport the products.

Equipment of one of Magnolia's chief gaugers and seven of his gaugers in the Illinois area

Writing Ticket and Making Shut-off Essential Part of Gaugers Work

A PETROLEUM ENGINEER FEATURE

Errors eliminated by adoption and close observance of routine method of procedure

By OTTO D. STALLARD, Jr.
Division Superintendent, Magnolia Pipe Line Company

IN a recent issue of *The Petroleum Engineer*[1], the routine necessary to make the "turn-on" of a tank of oil in the field to comply with the A.P.I. Code was described. To end the subject at that point leaves the job only half done, so it is essential that the run be completed by "writing the ticket" and making the "shut-off" by regular routine methods.

All gaugers should carry a seal book, field book, and proration book and post each daily. The seal book is used to keep a record of regular seals and the tanks on which they are applied, double checking the old seal at the stop, from the stop to the run book, then to the seal book. The field book is used to keep a complete record of each battery or lease and is indispensable for checking purposes and also to relief gaugers taking over the district. The proration book is used to keep a record of the daily runs against the daily proration so that the actual standing of each lease can be readily ascertained.

[1] "Improved Technique in Measuring, Sampling, and Testing Crude Oil," by Otto D. Stallard, Jr., *The Petroleum Engineer*, Midyear, 1940.

Writing the Run Ticket

After the inspection of all "turn-ons" for the day are made and skeleton tickets are made to cover, the gauger should then complete the run ticket as nearly as possible, checking closely with the seal book and the field book. The ticket number, second measurement, second b.s. & w. test on tank bottom, new seal number, date and time the "shut-off" is actually taken, the signature of the gauger and of the producing representative witnessing the transaction should all be a part of the completed record.

If each skeleton ticket is properly written-up from the field book, checked from the seal book, carefully checked on the "turn-on" and the "shut-off" and again at the time of filing, it should be correct.

Do not rely on memory, but check and double check all tickets; memories have failed.

Gauger's errors are uncalled for and can be reduced to a minimum by checking and double checking. There are approximately 50 chances on a single run ticket to make an error when gauger's calculations, erasures,

OTTO D. STALLARD, JR.

entered the employ of the Pipe Line Department of the Prairie Oil and Gas Company in Illinois in February, 1910—Spent eight years with Prairie as telegraph operator, oiler, and stationary engineer—Was a radio operator in the United States Army for two years—For the last 21 years he has been employed by the Magnolia Pipe Line Company as gauger, and general superintendent of gaugers, and general superintendent of the Central Division with headquarters in Dallas, Texas.

MAGNOLIA PIPE LINE COMPANY

Form X-###

Ticket No. _____ 19___ Dist. No. _____

Owner _____

Farm _____ No. _____

Well Nos. _____

Tank No.	Gauge	Feet	Inches	Gauger's Calculations	
	1st. Mst.				
Size	2nd. Mst.				
Tank Bottom	B.S.&W.	Feet	Inches	Barrels	Frac.
Ht. of Connection ___Ft. ___In.	1st. Mst.				
Connect. Clearance Per Cent	2nd. Mst.				

Indicated Gravity_____ Temp._____ Corrected to 60° _____

Tank Temp. Steamed_____ Cold_____ Method of Sampling _____

In sump'n_____ (dot) _____ Per cent B.S.&W. _____

By _____ To _____ Sta. No. _____

Furnished by _____ No. _____

Spl. Seal No. Used _____ On _____

Reg. Seal No. Old _____ New _____

Time - - M.	1st. Mst.	Gauger
Date - -19		Witness
Time - - M.	2nd. Mst.	Gauger
Date - -19		Witness

The crude petroleum oil represented by this ticket was received and runs as the property of the MAGNOLIA PETROLEUM COMPANY on its tenders of shipment to this company.

Sample run ticket

and retraces are counted, so extreme care must be taken or mistakes will be made and charged against the gauger monthly.

Shut-Off Routine

This is the shut-off routine that should be observed:

1. Carry run book.
2. Carry seal book.
3. Carry wrench when needed.
4. Carry equipment case.
5. Set the case at the foot of the stairs or some other clean place.
6. Shut-off tank; if more than one tank make shut-off from left to right.
7. Move dart up from the bottom of the stop with the left hand.
8. Run seal through dart hole with the right hand.
9. Snap seal so that the number is readable. Leave old seal on top for checking purposes.
10. Break bleeder seals. Place on tank stop for checking run.
11. Carry equipment case to the top of the tank.
12. Place case on the right side of the gauge hatch at a 45° angle.
13. Gauge tank; if more than one tank gauge tanks from left to right.
14. Re-check gauge.
15. Clean gauge line and bob and replace in equipment case. Always disconnect bob.
16. Thief tank bottom.
17. Check oil at the outlet connection and the clearance level.
18. If there is any question regarding the b.s. line, take sample for centrifuge test.
19. If bottom was close on the turn-on, take sample and grind to prove tank needs cleaning. (2 percent or less merchantable oil at clearance.)
20. Pour sample over the test-by-sight glass.
21. Determine the amount of b.s.&w. on tank bottom.
22. Wash thief in clean oil, bottom open, sample cocks open.
23. Set thief at an angle in hatch to drain.
24. Clean thief thoroughly.
25. Close bottom gently; close sample cocks.
26. Place cord or chain inside thief.
27. Place last rag used inside top of thief to eliminate drainage.
28. Place thief in case. Move to next tank on right.
29. Set case at the foot of the stairs in a clean and dry place.
30. Write up ticket in front of the tank shut-off.
31. Put ticket number on run ticket at this time as well as the shut-off gauge, second b.s.&w. test, new seal, time and date of shut-off, and name of gauger making the shut-off.
32. Check ticket number with last three numbers on new seal.
33. Check code number on ticket with code number on tank.
34. Check tank number on ticket with number on tank.
35. Check first measurement with oil height.
36. Check second measurement with the outlet connection.
37. Check b.s.&w. on tank bottom with pipe-line connection for clearance.
38. Check old seal left on stop with old seal on ticket.
39. Check new seal applied to stop with new seal on run ticket.
40. Check numbers of special seals broken with specials on run ticket.
41. Throw old seal and old special seals in container outside the firewall.
42. Check seal book, finish the (X) in double checking the old seal and tank number on seal book with that shown on the run ticket.
43. Enter date, ticket number, tank number, and new seal as applied on the shut-off on the seal report at this time, checking closely.
44. Have producer's representative sign the ticket as witness.
45. Check plain back or general office copy of run ticket carefully. Note that the ticket number, code number, tank number, size, first measurement, second measurement, gravity temperature, tank temperature, steamed or cold, b.s.&w. in suspension, and the gravity or power supplied specially are correct and readable.
46. If correct tear the original out and hand to producer's representative.
47. Look the battery over, see that everything is O.K.
48. Pick up wrench, equipment case, run books, and seal books.
49. Place them in their proper place in the equipment rack of the car.
50. Move on to the next battery.

Calculations

With the "shut-off" complete, the gauger should figure his runs for filing. He should figure each ticket on paper, check the code number, tank number,

Reproduction of page from seal record book

Form X-### S.M.

SEAL RECORD

DATE	TICKET	TANK	SEAL	CHECK MARK

SHELL

SMITH PRESSURE VESSELS

TWO GREAT NAMES

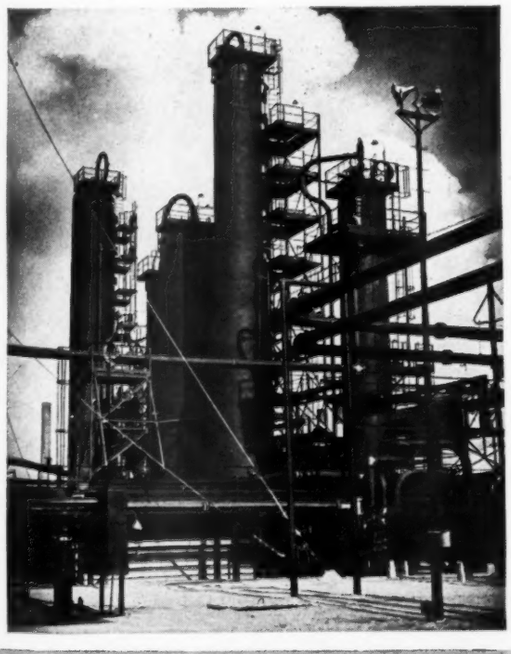
ONE GREAT JOB!

Above—Smithlined Coking Section Fractionating Side Cut Stripping Column, 5'x20', lined with 5/64" alloy.

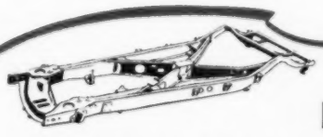
THE wholly reconstructed Wood River Refinery of the Shell Oil Company embodies the most advanced practice in modern refinery engineering.

It was, therefore, only natural for the executives of this refinery to turn to A. O. Smith for pressure vessels with corrosion-resisting alloy linings. Smithlining—or bimetallic construction—was pioneered by A. O. Smith. Today it is used and accepted wherever corrosion problems exist. Smith regards each corrosion problem as requiring individual solution—and Smith's successful solution of these problems is one of the reasons why 90 per cent of the high-pressure vessels now in service are of Smith manufacture.

A. O. Smith Corporation, Milwaukee, Wisconsin. Offices at New York, Pittsburgh, Chicago, Tulsa, Dallas, Shreveport, Houston, Corpus Christi, Los Angeles.



Left—Smithlined Fractionating Column of Dubbs Cracking Unit in Shell's Wood River Refinery. Size: 11'x53'-4", with 1 3/16" and 1 1/2" wall, lined with 5/64" alloy.



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A. O. Smith, founded in 1874, makes pressed steel chassis frames for automobiles at the rate of 12,000 per day.

The Smith plant covers 125 acres and employs some 5,000 men.

25,000 tons of steel products, on an average, leave the Smith plant monthly—the largest consumer of rolled plate in the U. S.

A.O.SMITH

CORPORATION

Milwaukee, Wisconsin

PIONEER MANUFACTURERS OF ELECTRIC-WELDED

Pressure Vessels

Casing · Line Pipe

OWNER

FARM

LOCATION

WELL NUMBERS

ALLOWABLE

	OIL RUN	TOTAL OIL RUN	Allowable	TOTAL Allowable	Over or Short
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
NET					
PREVIOUS					
TOTAL					

Sample page from proration book

owner and farm on the run ticket against the same on the tank table. After the barrels and fractional barrels on the "shut-off" are deducted from the barrels and fractional barrels on the "turn-on" to obtain gross barrels run, the figures should be checked by addition.

The gauger should figure each ticket the second time, placing such information directly on the run ticket, checking against errors as above recommended and then checking the figures on the paper against the figures so placed on the run ticket.

The gauger should read over each run ticket carefully after it has been figured in order to see that the ticket is properly filled out. As the run tickets are in reality a draft on the purchasing company for payment in dollars and cents for so much oil in barrels and fractional barrels, they must be correct.

The run tickets for each 24-hour period, ending 7 a.m., should be filed in numerical order and the number of tickets, date, time filed, and signature of the gauger placed on the back of the last ticket before it is turned over to the telegraph office for sending, or is placed in a regular run ticket envelope for mailing to the general office of the purchasing company, completing business for that particular day.

The interest that most companies

X-1116

Dist. No. Page No.

Owner

Farm

Wells

Location

County State

TANK	SIZE	Oil Height	F. L. Corr.	CAPACITY INCH	CAPACITY FOOT

Gravity Temp. Corrected

Steamed Cold B. S. & W.

By To

Furnished By

Allowable Daily Prodn.

Machinery Make

Size Number

Owner

Remarks:-

Sample page from field book

have taken to improve the personnel and means and methods of making inspections are gratifying indeed and too much credit cannot be given to the American Petroleum Institute, its secretary, C. A. Young, and Code No. 25 toward creating a decided improvement in the Measuring, Sampling, and Testing of Crude Oil.

Road Oil Sales Increased 5 Percent in 1939

INCREASED construction of oil-treated macadam, gravel, and sand-clay highways resulted in an increase of 5 percent in refinery sales of road oil, from 7,741,843 bbl. in 1938 (revised figures) to 8,108,400 bbl. in 1939, according to reports submitted to Secretary of the Interior Harold L. Ickes by the U. S. Bureau of Mines. As a result of lower prices, the value at the refineries of sales of road oil decreased 11 percent, from $9,464,114 (revised figures) in 1938 to $8,458,600 in 1939.

Increases occurred in the following districts: Indiana, Illinois, Kentucky, etc.; Oklahoma, Kansas, and Missouri; Texas; Arkansas and Louisiana, and California. Decreases in the East Coast, Appalachian, and Rocky Mountain districts were insufficient to offset the general increase.

Of the road oil sold in 1939 only 293,100 bbl., valued at $592,300, were made from foreign petroleum, imported chiefly from Venezuela and Mexico. Of the road oil made from foreign crude, 98 percent was sold by refineries of the East Coast district in 1939.

Petroleum refineries in the United States reported the production of 7,868,000 bbl. of road oil in 1939 compared with 7,788,000 bbl. (revised figures) in 1938. The refinery output of road oil in 1939 was augmented by 1,222,700 bbl. of other petroleum products, chiefly fuel oil, transferred to road-oil stocks compared with 722,100 bbl. similarly transferred in 1938. Stocks of road oil and transferred oils increased 22,000 bbl. during 1939, compared with an increase of 13,000 bbl. during 1938. Consumption of road oil at refineries in operations, transfers, losses, and adjustments were 960,300 bbl. in 1939 compared with 755,257 bbl. in 1938.

The average value of road oil sold in the United States f.o.b. refinery decreased from $1.22 per bbl. (revised figure) in 1938 to $1.04 in 1939. The principal decreases were in the East Coast district (from $1.64 in 1938 to $1.37 in 1939); in the Indiana, Illinois, Kentucky, etc., district (from $1.36 to $1.02); in the Louisiana-Arkansas district (from $1.35 to $0.95); in the Oklahoma-Kansas-Missouri district (from $0.92 to $0.74), and in California (from $1.02 to $0.86). Gains in Texas (from $1.50 to $1.56) and in the Rocky Mountain district (from $1.26 to $1.34) were insufficient to check the general decline.

Temperature Log Reveals Gas-Oil Contact Plane

Geothermal data, properly interpreted, yield valuable information concerning well conditions

By
WALLACE A. SAWDON
Pacific Coast and Foreign Editor

THE data obtained by making temperature surveys in oil wells have been used for various purposes during the last year or two. Among the applications of such surveys have been the location of the top of cement behind casing, detection of points of entry of gas or water, and the determination of other points at which conditions cause a slight change of temperature. Surveys have been made for these various purposes in flowing, pumping, and shut-in producing wells, in drilling wells, and in wells ready for completion. Of considerable interest was the recent location of the point of contact between the gas- and oil-bearing strata of a producing zone by temperature indication and the resultant shutting-off of the upper gas so indicated to reduce the gas-oil ratio when completing the well.

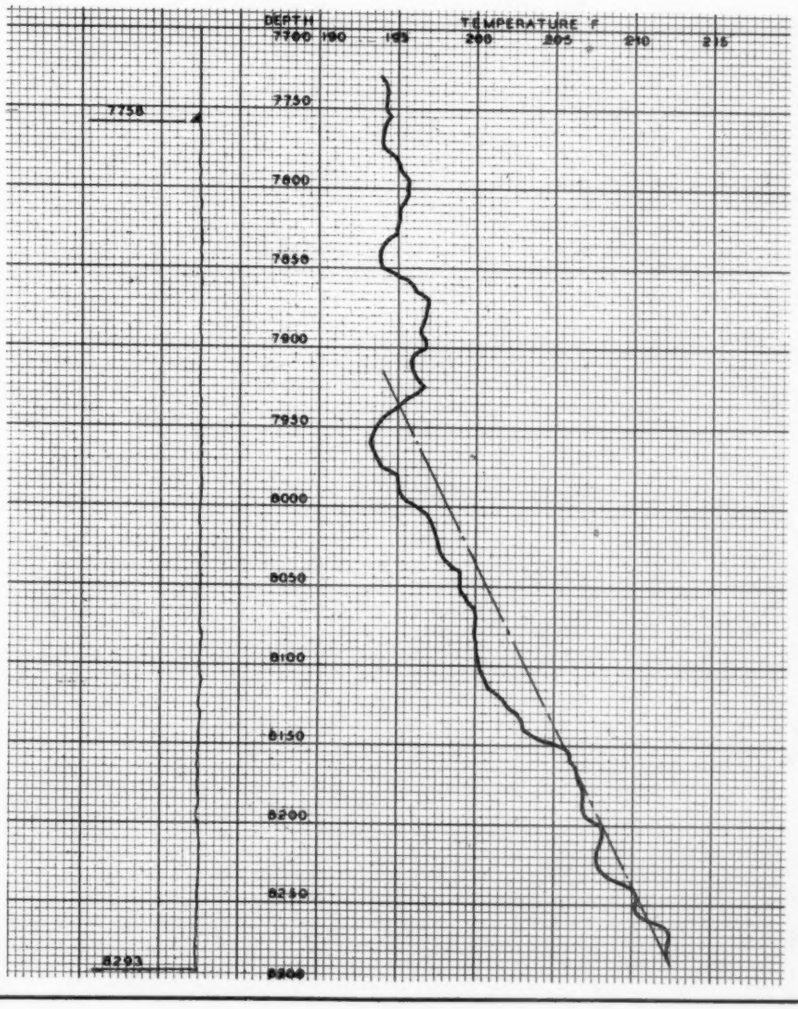
Although other means have been used to locate the interface between the gas and oil in a productive zone, the speed at which the survey was made and its accurate check of other determinations indicate the possibilities of temperature determinations in drilling wells. The equipment employed is a newly designed instrument that is run in the well on piano wire with a conventional measuring line hoist. The temperature record is made on film moving at a constant speed, which provides synchronization with depth measurements at any time by means of a stop watch started at the same time as the instrument mechanism.

The graph shown in Fig. 1 gives the temperature reading of a well in the Belridge field, California, under the following conditions: With 7-in. casing cemented at 7758 ft. the hole was drilled to 8293 ft. It was known that this open hole passed through a productive zone consisting of a lower stratum producing oil and an upper stratum producing free gas. Before making the temperature survey to locate the plane of contact between the oil and gas strata, mud was circulated for six hours with drill pipe on bottom. The drill string was then pulled and the hole allowed to stand for four hours. The mud fluid in the well was thus in a completely quiescent stage when the instrument was run-in. The survey required one hour.

The reciprocal geothermal gradient of the Belridge field is greater than those of most other fields in the state and at 8300 ft. is 235°F. By circulating with mud fluid for six hours the temperatures in the hole were reduced; then, while the mud remained quiescent, the heat transfer from the formations to the mud resulted in an increase of the temperature of the mud. With mud holding all fluids in the hole in equilibrium, there was no movement of gas or oil into the bore and thus no influence on the transfer of heat as the mud gradually assumed natural earth temperatures. In the gas zone this heat transfer proceeds more slowly than in the oil zone or shale and it is by locating this lag in heat transfer through the lower temperatures that the gas zone is determined.

The broken line in Fig. 1 indicates the temperature gradient of the fluid

Fig. 1



in the bottom of the hole at the time the survey was run. At a depth of 8155 ft. the temperature shows a definite decrease and thus indicates the plane of contact between the oil and gas strata of the producing zone. From that point to approximately 7960 ft. the temperature rise lags behind that in the rest of the hole and shows the extent of the gas-bearing formation.

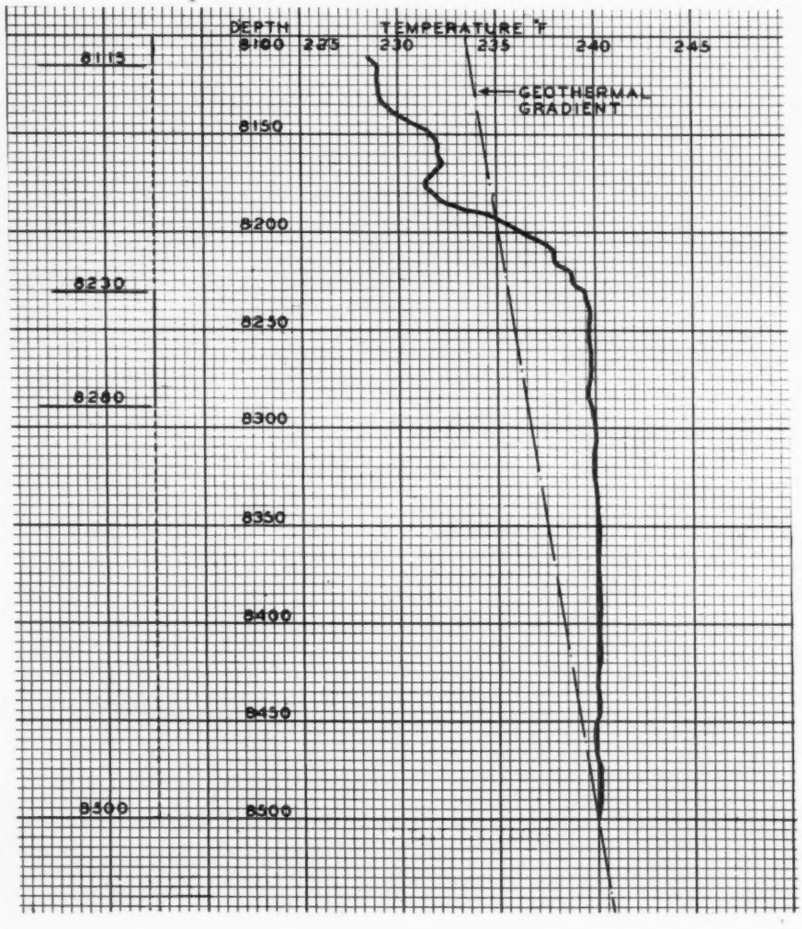
In completing the well, 662 ft. of 5-in. liner was run to bottom at 8293 ft. and was cemented at 8171 ft. a little below the gas-oil interface. The lower 122-ft. liner section was perforated, the section above being blank pipe cemented into the 7-in. casing string.

Gas-oil ratios in the Belridge field vary considerably and in some wells are as high as 100,000 cu. ft. per bbl. The initial production of the well here considered was 756 bbl. of 30.1 deg. A.P.I. oil cutting 0.7 percent water. The casing pressure was 695 lb. per sq. in. and the tubing pressure, 102 lb. per sq. in. The well produced 2,280,000 cu. ft. of gas per day, resulting in a gas-oil ratio of 3000 cu. ft. per bbl. of oil.

A temperature survey using the same instrument was made in an offset well that had been completed to flow from both the oil and gas strata of the producing zone through perforated sections of liner separated by blank pipe as shown in Fig. 2. The 7-in. casing in this well was cemented at 8074 ft. and 4-in. liner, perforated as indicated in the drawing, was set on bottom at 8500 ft. At the time the temperature survey was run the well was flowing 131 bbl. of 37 deg. A.P.I. oil per day with a cut of 45 percent water. The pressure on the casing was 1100 lb. per sq. in. and that on the tubing 700 lb. per sq. in. The gas flow was 2,320,000 cu. ft., which made the gas-oil ratio (excluding the water from the calculation) approximately 27,000 cu. ft. per bbl. of oil.

The temperature curve of Fig. 2 shows a rather constant temperature for the fluid, this temperature being approximately as at the bottom of the hole. It is logical for it not to follow the geothermal gradient inasmuch as the fluid column maintains its heat and the actual change of temperature from bottom to top of the oil stratum is slight. The curve begins showing a definite break indicating lower temperature as soon as the column reaches the top of the blank pipe above which the gas enters through the upper perforations.

Fig. 2



The bottom point of gas entry into the bore of the well is clearly defined in the two graphs. The cause of temperature decrease, however, is not the same in the two cases. The survey shown in Fig. 1 was made in a well in which the fluid was cooler than the formation and the instrument was run at a shut-in period during which the fluid temperature in the hole was increasing. The low temperature of the mud opposite the sand body was the result of decreased rate of heat transfer from this body in comparison to the rate from the oil body below and the shale above.

In the flowing well, as illustrated in Fig. 2, the lower temperature was caused by the flow of gas into the bore of the well and the consequent decrease of temperature caused by the reduction in gas pressure. The heavy flow of gas from the upper stratum of the producing zone was sufficient to cool the entire flowing column of fluid in the well and as further expansion of the gas took place under constantly reducing pressure as the fluid passed up the hole, a further consistent decrease in temperature was recorded. Also to be considered is the effect of specific heat of the oil-water mixture from the bottom of the well as compared with the specific heat of the mixture where 20,000 cu. ft. of gas per bbl. of oil were picked up.

It has been argued that the lower temperature at the gas sand in a drilling well that has been shut-in while full of mud fluid is caused by the expansion of gas. If the well is in a quiescent condition and the mud is performing its function of keeping formation fluids from entering the bore of the well, there seems to be no chance for gas to expand and reduce the temperature. The important fact is, of course, that the mud column opposite the gas body does have a lower temperature and that from this temperature the contact plane between the oil and gas strata can be located. On the other hand, if the temperature survey made in a quiescent well is not run before the mud fluid assumes the temperature of the geothermal gradient there will be no temperature indication of oil and gas separation. Misleading information may then result.

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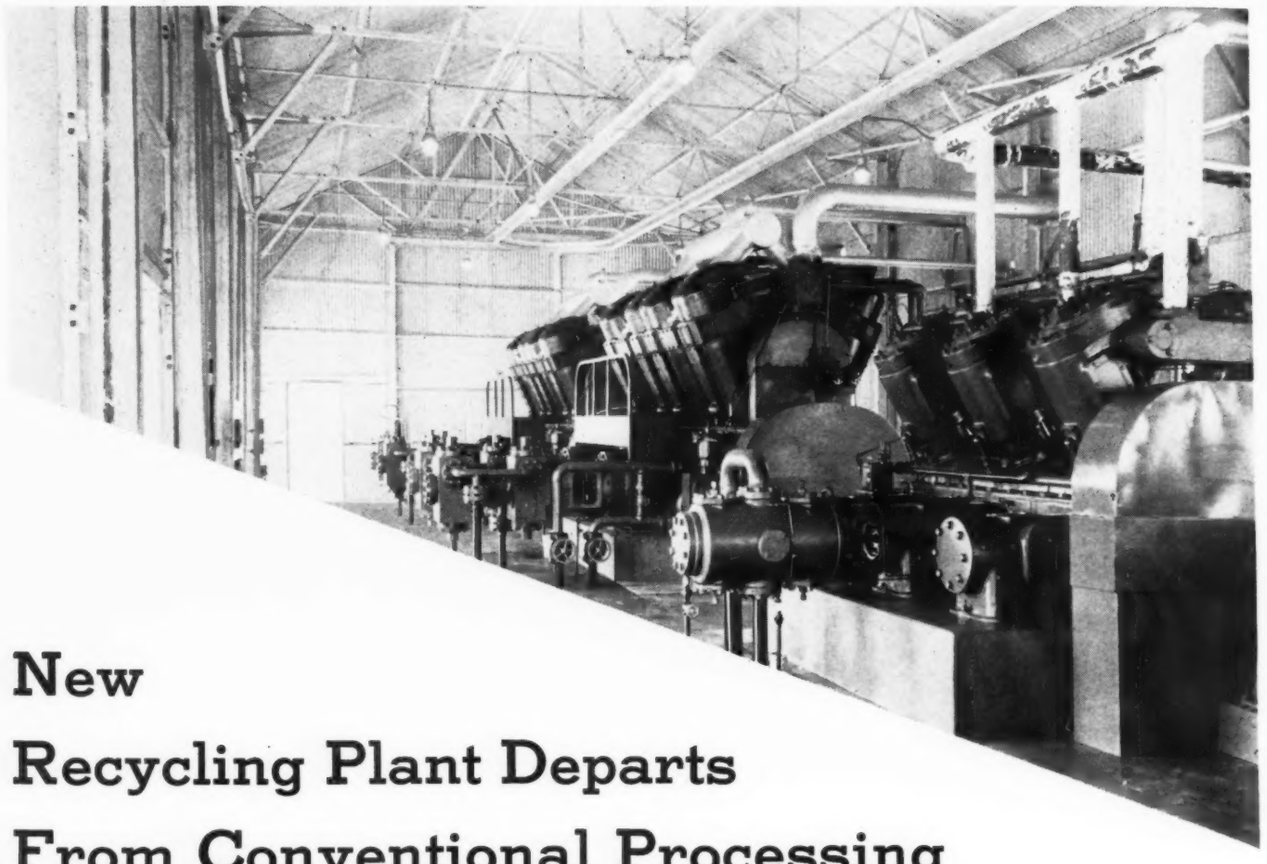


New Recycling Plant Departs From Conventional Processing

Two-compartment dephlegmator operates at 40 lb., producing naphtha overhead for blending with butane-free gasoline

IN THE La Rosa field, Refugio County, Texas, the Coronado Corporation has completed and is now operating its 46,000,000-cu. ft. recycling plant. The products of the plant, which is operated on the absorption principle, at present are stabilized distillate and butane, although the design is such that all grades of motor fuel, special solvents, propane, butane, kerosine, naphthas, and natural gasoline can be manufactured.

Operation is at high pressures. Wellhead pressure of the supply wells is 2250 lb. per sq. in. gauge. The gas from these wells enters a common gathering system and upon arriving at the plant and before entering the two inlet scrubbers the pressure is reduced to 1800 lb.

In the scrubbers gas hydrates and partial distillate condensate are caught, the gas passing to the two high-pressure absorbers, which are 36 in. in diameter and have a 2-in. wall thickness. The operating pressure of these absorbers is 1800 lb. per sq. in. gauge and through them absorption oil is circulated in the ratio of 4 gal. to 1000 cu. ft. of gas.

From the high-pressure absorbers the rich oil is pumped to the 4 by 28 rich-oil vent tank where methane, ethane, and some of the propane are flashed to the intermediate absorber, which is operated at a pressure of 120 lb. Butanes and heavier are absorbed in this column and enter the rich oil stream, passing through heat exchangers and preheaters to enter the still. At a pressure of 40 lb. and a temperature of 407°F. the rich oil is stripped, the vapors passing to the dephlegmator.

At this point a change has been made from the conventional method of processing. The dephlegmator has two take-off compartments. Kerosine is drawn-off from the middle of the column and naphtha from the top compartment. Both the kerosine and the naphtha streams are discharged to side strippers and made into special naphthas, finished kerosine, and gas oil.

The dephlegmator column is operated at a pressure of 40 lb. At the base of the column are two dehydrators, one for each take-off compartment. The cuts from the compartments, before going to the strippers, first pass through the dehydrators, emerging at the top. Naphtha and kerosine enter the top of the strippers, in which they are agitated by steam, the top being refluxed to control endpoint for special products.

The dephlegmator overhead, which in this operation is unstabilized natural gasoline, goes through primary and secondary coolers into the reflux accumulator tank. From there it passes to the rundown tank at which point the stabilizer charge pump takes suction and pumps into the depropanizing column, operated at 300-lb. pressure and 290°F. temperature. Here the natural gasoline is depropanized.

The bottoms from this column are discharged into the middle of the debutanizing column, operated at a pressure of 100 lb. and a temperature of 230°F. Butane is removed in this column, leaving as the base product a butane-free blending stock. This prod-

uct is then blended with naphtha from the dephlegmator top to produce a finished gasoline.

Storage is supplied by six 12 by 52 hemispherical-head tanks each having a capacity of 40,000 gal.; four 6 by 32 butane tanks each having a capacity of 5000 gal., and one 10,000-bbl. Hortonspheroid.

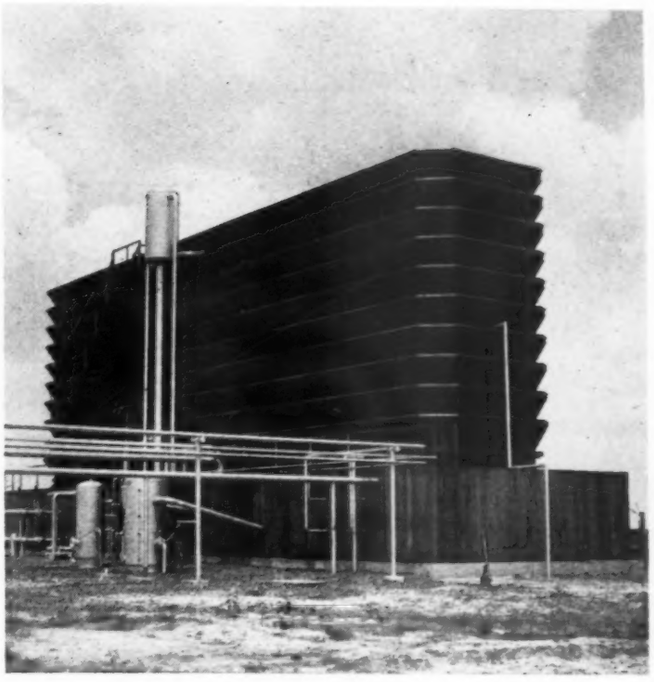
Lean oil coming off the still bottom is discharged through a heat exchanger and cooling coils to the suction of the low-pressure lean-oil pumps, being then discharged to the suction of the high-pressure lean-oil pump. A side stream of oil is discharged from the low-pressure lean-oil pump over the intermediate and low-pressure absorbers.

The high-pressure lean-oil pump is driven by a 225-hp. gas engine situated in the compressor room, delivering at the rate of 150 gal. per min. at a suction pressure of 120 lb. and a discharge pressure of 1850 lb. Incidentally, this gas-engine unit also powers a 6½ by 12 recompressor cylinder that takes suction at 40 lb. from a rundown tank, recompresses the gas, and discharges into the depropanizing column at a pressure of 300 lb.

Pressure Maintenance

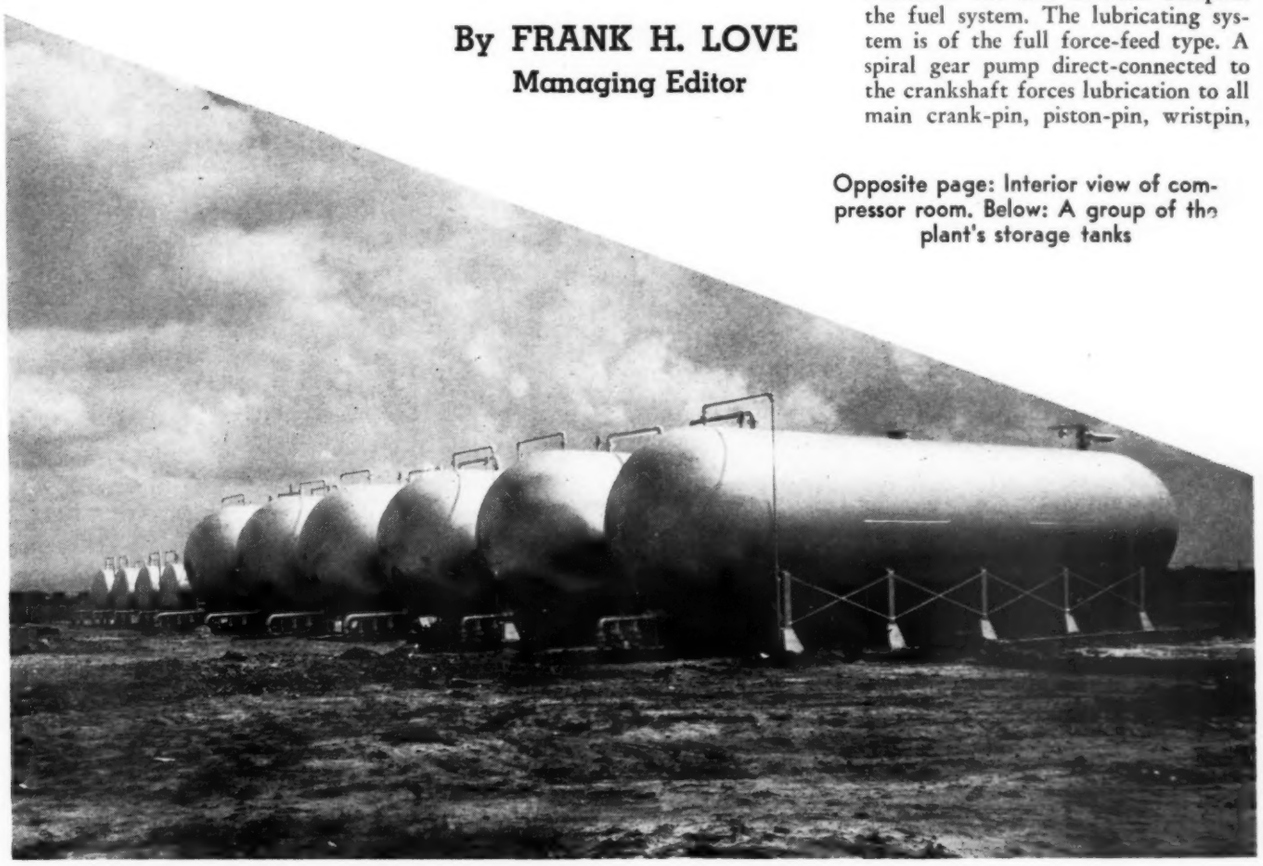
Dry gas coming off the absorbers is scrubbed prior to entering the suction of the two 650-hp. compressors for injection into the producing formation at a depth of 5800 ft. Suction pressure is 1800 lb. per sq. in. and discharge to key wells is at a pressure of 2600 lb. There are two input wells and the gas injection is simultaneously through 7-in. casing and 2½-in. tubing.

The two 650-hp. (at 300 r.p.m.) compressors are vertical V-type, double-acting, 8-cylinder units having two 4⅝ by 15 compressor cylinders. The power cylinders have a 14½-in. bore and 18-in. stroke. Alloy cast-iron honed liners are a part of the power cylinder equipment. Power cylinder heads are of valve-in-head type. Power pistons are cooled by an oil spray from the top of the connecting rods. A low-pressure fuel regulator, a fuel gas cock, and a mixing valve that automatically maintains the fuel mixture comprise the fuel system. The lubricating system is of the full force-feed type. A spiral gear pump direct-connected to the crankshaft forces lubrication to all main crank-pin, piston-pin, wristpin,

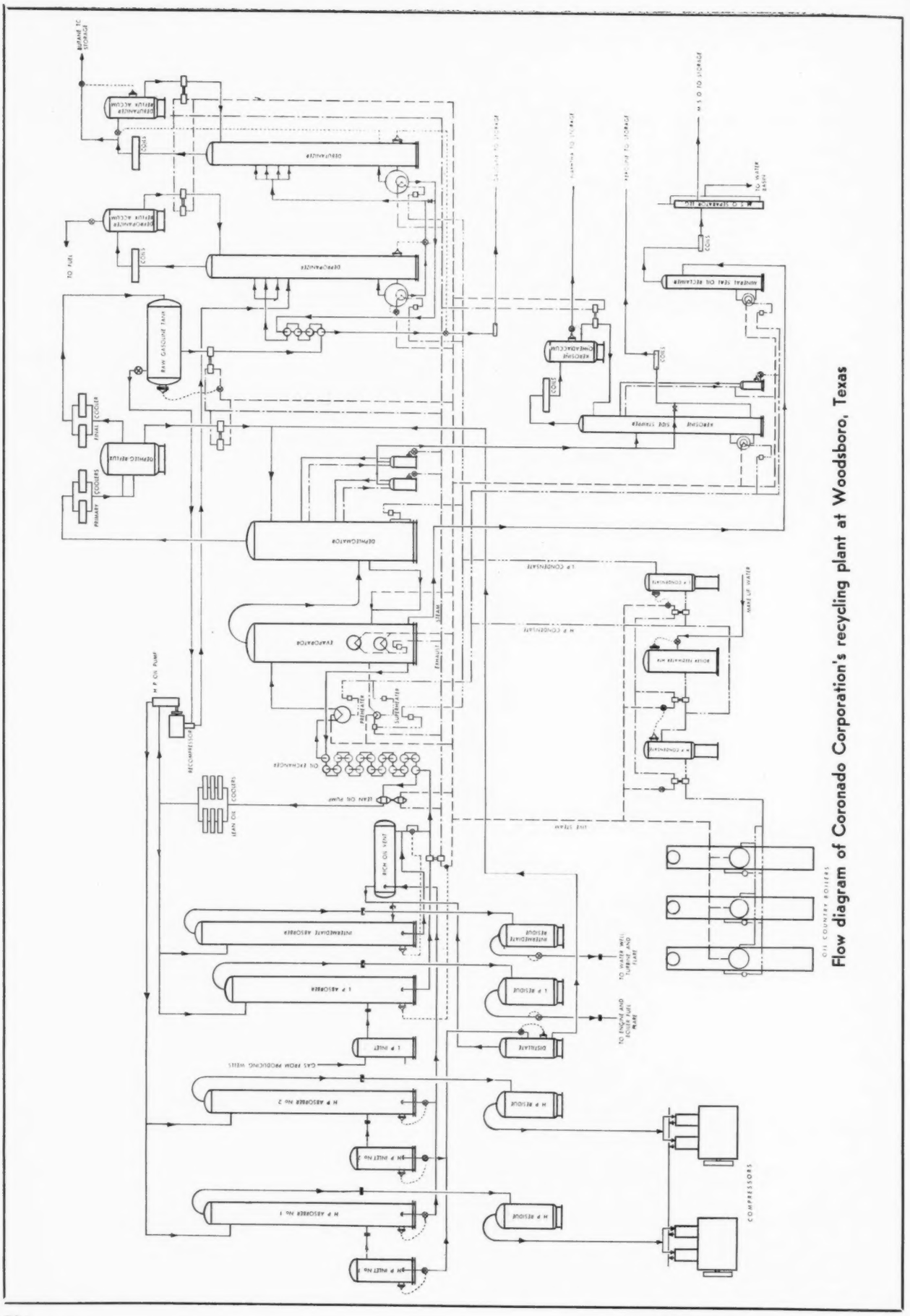


Atmospheric-type cooling tower with capacity of 3000 gal. per min.

By FRANK H. LOVE
Managing Editor



Opposite page: Interior view of compressor room. Below: A group of the plant's storage tanks



Flow diagram of Coronado Corporation's recycling plant at Woodsboro, Texas

Exclusively BRADEN

BRADEN Boiler House and Compressor Building, with processing area and cooling tower, in the new recycling plant at Woodsboro, Texas.

IN the construction of the new recycling plant of the Coronado Corporation at Woodsboro, Texas, BRADEN Sectional Steel Buildings were used exclusively. The several types of buildings used in this plant indicate the flexibility of design and the wide range of styles available with the use of BRADEN standard building sections.

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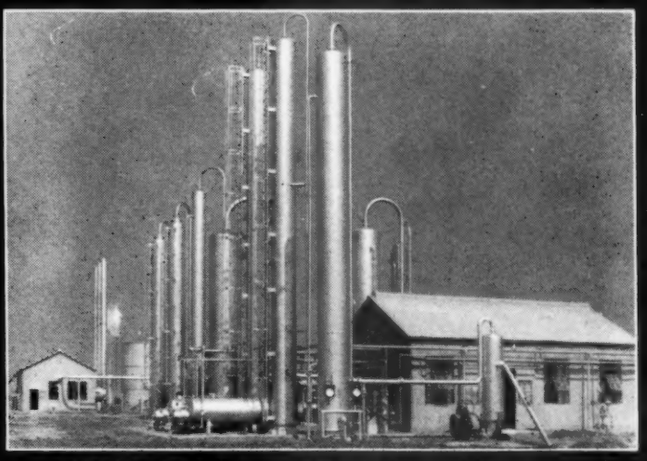

BRADEN Boiler House and Pump House with processing equipment in foreground.

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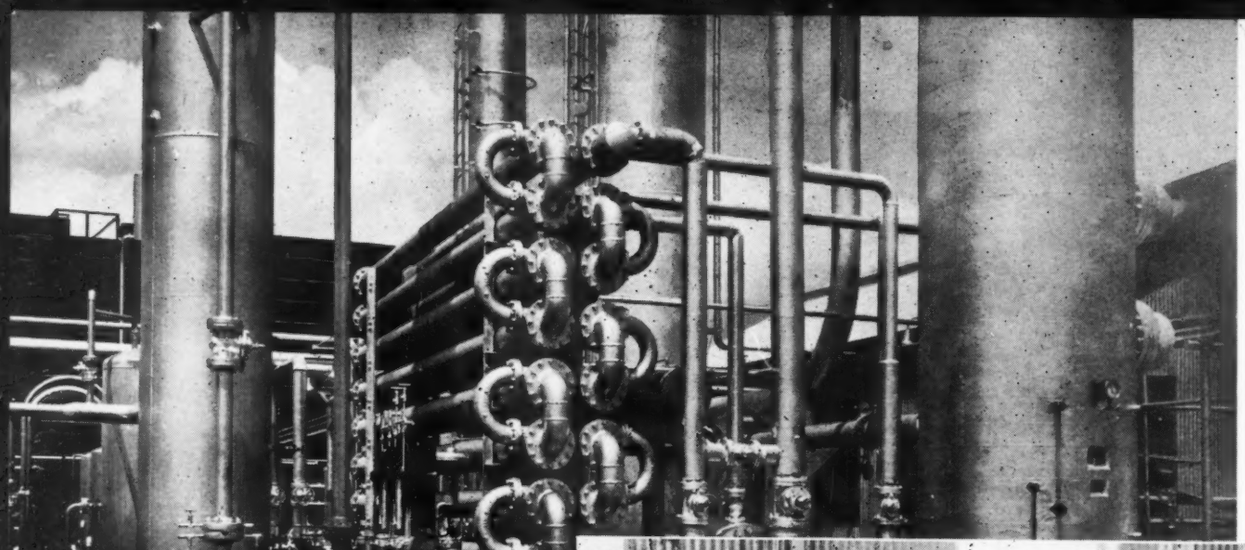
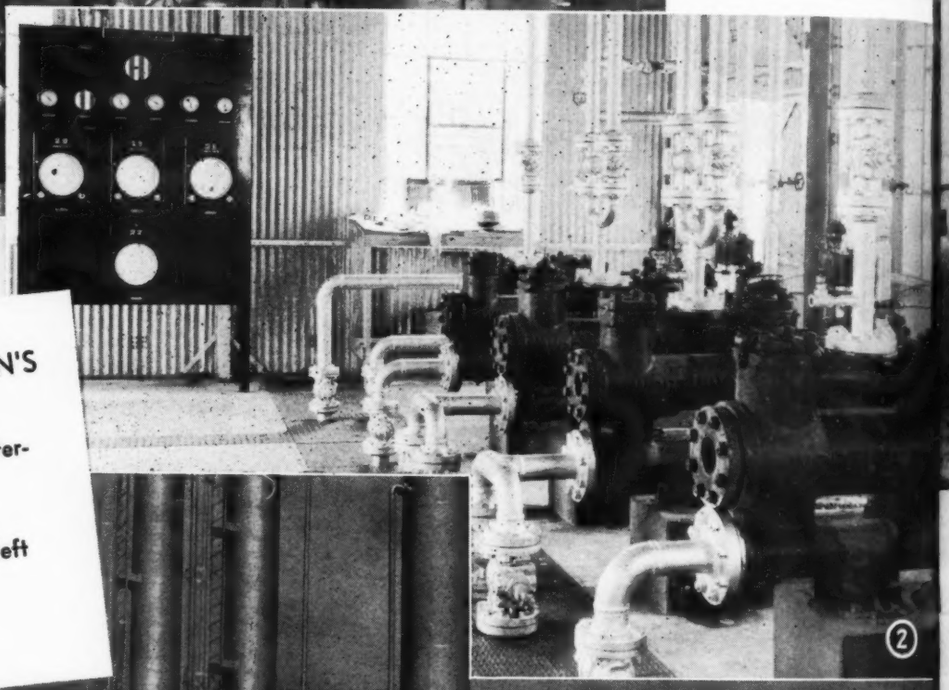
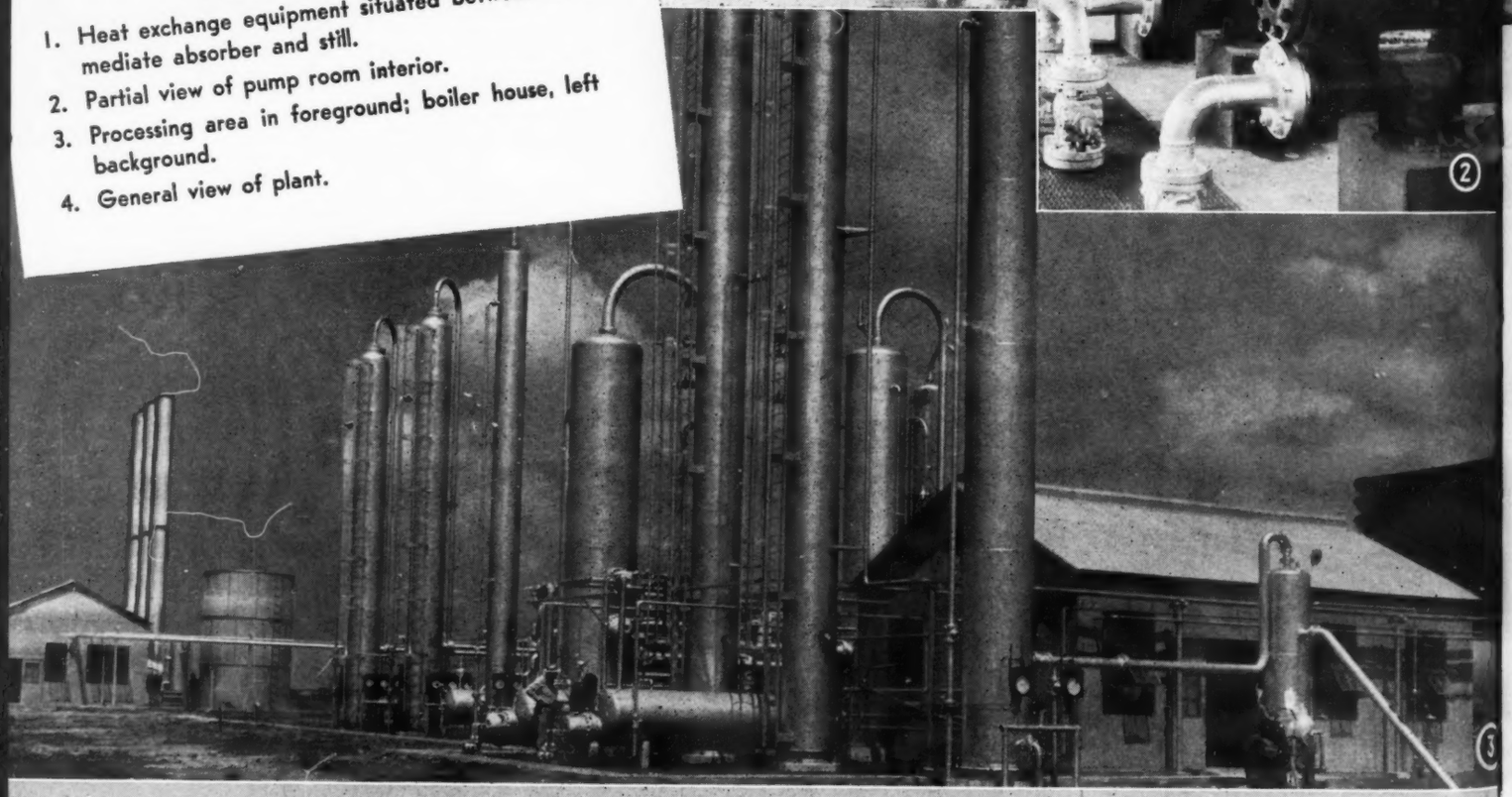
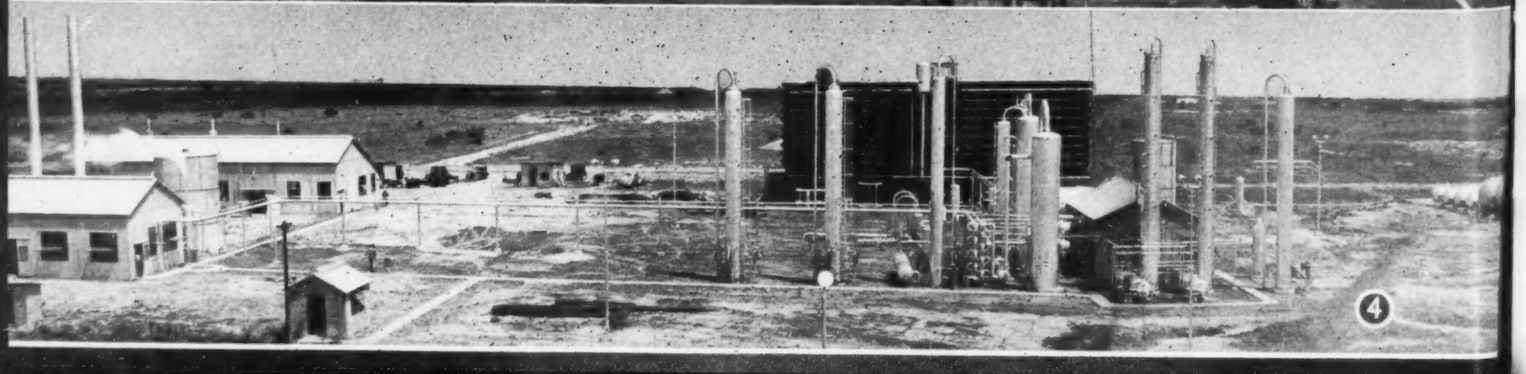


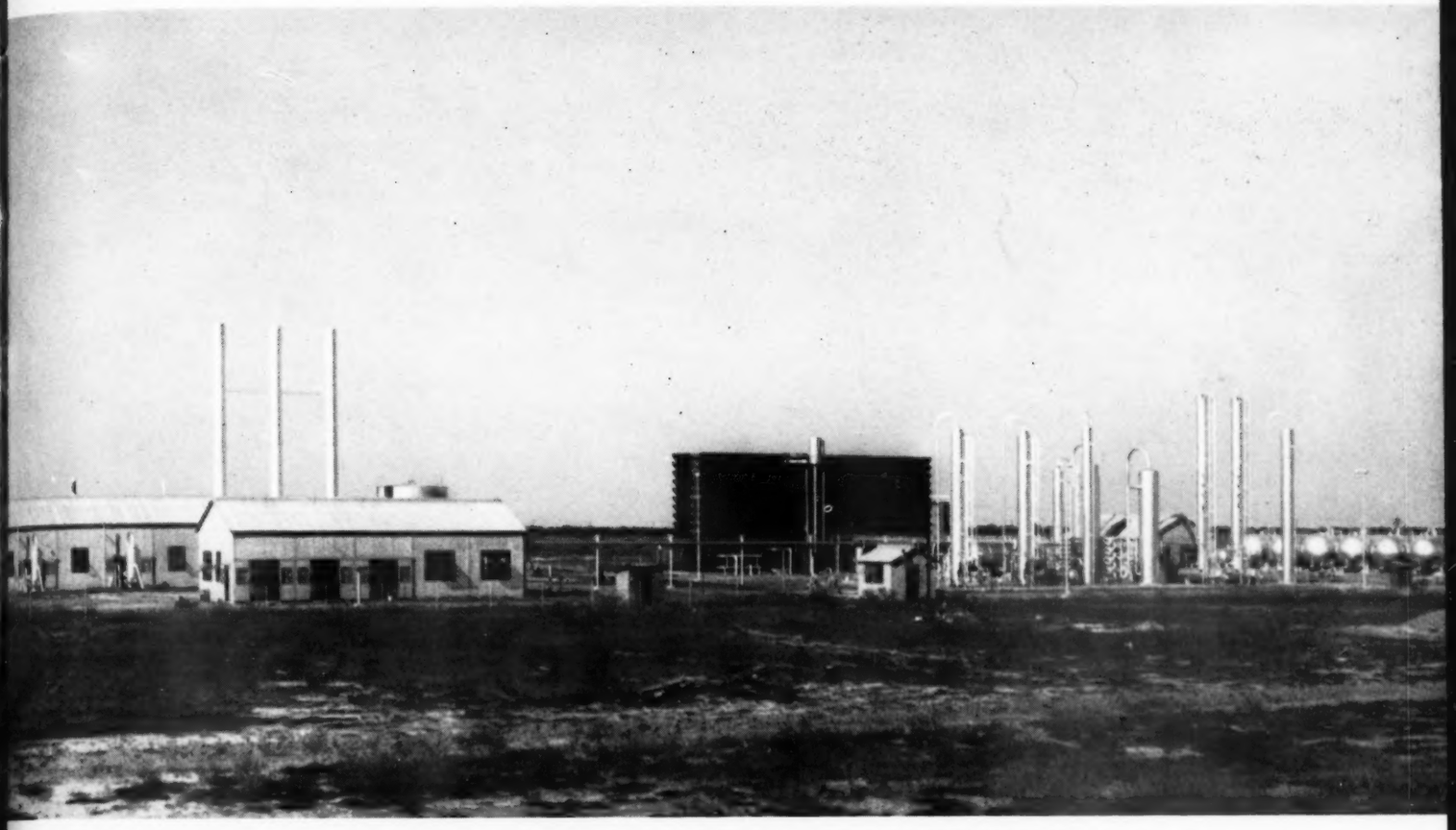


VIEWS OF CORONADO CORPORATION'S RECYCLING PLANT

1. Heat exchange equipment situated between intermediate absorber and still.
2. Partial view of pump room interior.
3. Processing area in foreground; boiler house, left background.
4. General view of plant.







A recent installation—Coronado Corporation's 46,000,000 cu. ft. plant in the LaRosa field, Texas.

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crosshead pin, and camshaft bearings, crosshead shoes, and rocker arms. A separate force-feed lubricator has individual sight-feeds to each compressor cylinder and stuffingbox.

Steam Condensate System

Steam is condensed by a 2-unit system. The preheater discharges into the high-pressure system. Excess steam from the processing units and condensate from all water traps are dumped into the low-pressure system. Water from the latter is pumped into the high-pressure system, which discharges to the superheater.

Steam is supplied by three 125-hp. oilfield-type boilers operating at 290-lb. pressure. The boilers are equipped with high and low water alarms, water gauge columns, and feedwater regulator. Makeup water is from a 750-bbl. supply tank.

Producing Wells

The five producing wells are drilled to a depth of 5800 ft. and 5-in. casing strings have been set. Flow is through 2½-in. tubing and the wellhead pressure of 2250 lb. is reduced to 1800 lb. by an adjustable choke.

Main field lines are of 6⅝-in. diameter and laterals are 3 in.

Cooling Tower

The atmospheric-type cooling tower has 10 bays and a capacity for handling 3000 gal. of water per min. Water supply is from two wells drilled in the plant grounds, one to a depth of 300 ft., the other to a depth of 600 ft. Flow is by gas-lift, which boosts the water to an overhead tank situated at a level with the top of the cooling tower to which the water is discharged.

Power Generators

Electrical power is generated by a 18.7-kva., 15-kw., 480-volt, 22.5-amp., 60-cycle, 1800-r.p.m. steam-driven generator having an 80 percent power factor. A 0.5-kw., 125-volt, 4-amp. exciter is included with the generator.

Buildings

Buildings are of steel-frame construction and have a covering of corrugated galvanized iron. The main compressor building is 88 ft. 1 in. by 26 ft. 5½ in. by 68 ft.; the control room, 36 ft. 1 in. by 24 ft. 5 in.; the boiler house, 24 ft. 5½ in. by 60 ft. 1 in., and the generator house, 12 ft. 1 in. by 10 ft. 5½ in.

Pumps

The pumps, all of which are steam driven, consist of the following:

Condensate pumps—two 8 by 5 by 12, one operating at a pressure of 120 lb., the other at 150 lb.

Boiler feed pumps—two 8 by 5 by 12, operated at 300-lb. pressure. One serves as a standby.

A spare pump used for condensate, butane, etc.—8 by 5 by 12, operated at a pressure of 50 lb.

Tower bottoms pump—8 by 5 by 12; 50-lb. operating pressure.

Dephlegmator reflux pump and spare—8 by 5 by 12; 50-lb. operating pressure.

Stabilizer feed pump—10 by 6 by 12; 350-lb. operating pressure.

Stabilizer spare pump—8 by 5 by 12; 350-lb. operating pressure.

Stabilizer reflux pump—6 by 6 by 12; 350-lb. operating pressure.

Debutanizer reflux pump—6 by 5 by 12; 150-lb. operating pressure.

Rich oil pump—10 by 6 by 10; 200-lb. operating pressure.

Lean-oil pumps—two 3600-r.p.m. centrifugal pumps; and one 3¾ by 10 operating at 1750-lb. pressure.

Gasoline transfer pump—a 1750 r.p.m. centrifugal unit; 100-lb. operating pressure.

Loading pump—a 1750-r.p.m. centrifugal unit; 100-lb. operating pressure.

Gasoline Plant Construction Corporation, Houston, Texas, contracted the building of the plant.

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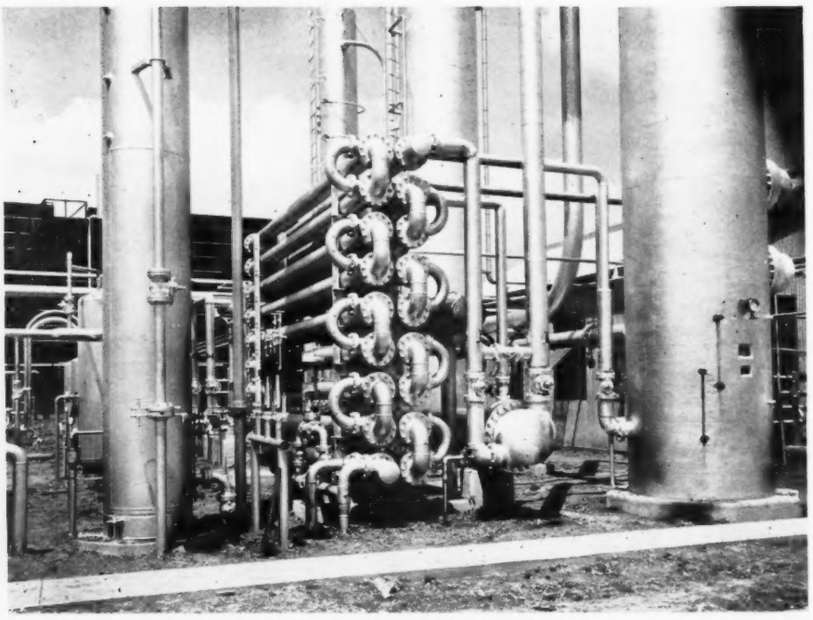

TULSA TYPE EQUIPMENT

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Dephlegmator	Debutanizer
Absorber	Reboilers
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Typical dump bailer pick-up with bailer and mixer

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
R. K. HENDERSON
District Engineer, Halliburton Oil Well Cementing Company

New Fast-Setting Cement Is Valuable Odd-Job Adjunct

Calcium sulphate cement useful in tamping of shots, protecting oil sands and bottom of the hole, and other subsurface work of special nature

A NEW gypsum cement of high strength is being used in the Illinois oil fields to advantage in special uses for which other materials are not readily adaptable. It is not intended as a substitute for the Portland cements, nor is it intended to replace them. It has, however, proved its worth in certain instances where available materials would not suffice.

This new cement is composed of 98 percent dehydrated calcium sulphate, to which has been added other chemicals to control the setting time. Setting is accomplished through the hydration of the material, resulting in a dense, hard, interlocking crystalline structure. The material is available on the market in four different setting times, namely, 30, 60, 120, and 180 minutes. The cement expands in the setting process, thus producing a very tight bond to steel and adherence to the walls of a hole. It will set under agitation and, when set, leaves no free water on the surface. Crushing strength of the material is approximately 2000 lb. per sq. in. shortly after setting. Very little heat is developed during the setting process.

Caution must be exercised in the mixing and placing of this special cement. The material has a definite setting time when mixed with reasonably pure water, but contamination with salts, sulphates, and bicarbonates in appreciable amounts, will accelerate the setting time. Certain organic impurities and soluble sulphides may retard the setting time. Whenever possible, a sample of the cement should be mixed with the water to be used, and allowed to set, to determine the exact setting time on any given job.

R. K. HENDERSON

was born in Honolulu, Hawaii, September 4, 1913—Attended High School in Tacoma, Washington—Graduated from Oklahoma University in 1935—For the last five years has been in the employ of the Halliburton Oil Well Cementing Company and at present is district engineer in Illinois, Indiana, and Kentucky for that company.

This new product has been found especially adaptable to the tamping of shots in the oil fields of the Illinois Basin with the use of a special type dump bailer. On one job in the Salem field, 150 quarts of nitroglycerine was tamped with 5 ft. of gravel and 12 sacks of the special cement at a depth of 1740 ft. The hole was fluid-filled above the tamp, and the resulting explosion lifted the fluid in the hole approximately 10 ft. Upon going back into the hole, however, it was found that the pipe was not damaged, the cement was not shattered, and the drilling-out time was 8 hr. This represents a material saving in time over the ordinary sand tamp. The dump bailer made two trips on this job, and the entire mixing and placing time was 60 minutes. A 24-hr. bomb was used.

On a well in the Hawthorne pool, the McCloskey lime was shot with 5 qt. of nitroglycerine tamped with 8 sacks of the calcium cement. There was only one foot of sand above the cave catcher and the bottom of the plug was one foot below the casing shoe in 4⅞-in. hole. When the shot was fired the pipe was protected and

the cement was not shattered. Drilling-out time was 8 hr.

A 10-qt. shot in the Cypress sand was tamped with 6 sacks of the cement above 5 ft. of rock on the cave catcher. The bottom of the plug was 4 ft. below the casing shoe in 6¼-in. hole. The plug was not shattered and the drilling-out time was 3 hr.

In another well, the Cypress sand was shot with 40 qt. in the Griffin pool and was tamped with 12 sacks of the new cement over 5 ft. of sand and gravel. The bottom of the plug was 6 ft. below the casing shoe in 5½-in. hole. No damage was done to the pipe, and the drilling-out time was 7 hr.

Common practice in the Illinois area is to use at least 5 ft. of sand and gravel above the cave catcher, with the top 2 or 3 ft. made up of crushed rock from one to two inches in diameter. This is desirable to keep the surge from carrying sand up around the bailer when dumping the cement. When the hole is full of oil, it is good practice to run a bailer or two full of water and dump on bottom. This tends to scavenge the walls of the hole and provide a better bond with the cement. Two or 3 ft. of water poured in the bottom of the bailer when the cement is run, will wet the walls of the bailer and keep the walls from robbing the cement of water of hydration. It will also help keep the bailer from bridging as well as scour ahead of the cement as it is dumped.

Bailers are made of light-weight drillable material in sizes from 3-in. to 5½-in. O.D. A new type dump bottom of special design operates very successfully in keeping the bailer from dumping when running into the fluid or in the hole below the pipe. When more than one run is required to dump sufficient material to tamp the shot, time is allowed for each dump to set before the next bailerfull is run. The quantity of material run per dump is dependent upon the size of the bailer, as is the number of joints of bailer run. Thus, for a 4½-in. bailer, six 20-ft. joints, each holding 8 sacks of mixed material, represents about the maximum per dump. With 3½-in. bailers, 12 joints holding 10 sacks of mixed material is about the maximum. In every case the fluid in the hole should be allowed to seek its static level before the cement is dumped so that there will not be a tendency for an unbalanced fluid column to move the tamp or sweep it away.

The accompanying illustration shows a typical dump bailer pick-up with bailer and mixer. The unit is designed to carry the bailer in 20-ft. joints. The mixer is mechanical, driven by a small gasoline engine. Water for mixing is carried by the unit in a tank at the rear of the cab. This water is pre-tested to make certain that it contains no impurities that might affect the setting time of the special cement.

The new cement has been successfully used when blowing out pipe opposite a section of oil sand. An artificial bridge is set in the casing just below the point at which it is desired to explode the bomb, and a cap of the cement is dumped on top of the bridge. The bomb is then set in the pipe and a cement tamp dumped on top of the bomb. The best results in this type of work have been where magnesium or aluminum pipe had been set opposite the sand section with the idea of coming back and producing from that section ultimately. A small bomb will completely burn up a short section of magnesium pipe.

Small amounts of the cement have been used in setting surface casing and conductor pipe. Usually this is run just behind the regular cement. It allows the operator to go right back into the hole and continue drilling while the regular cement is setting, his only loss of time being the setting time of the special calcium sulphate cement.

It has been found that the new cement forms an excellent plug to protect a formation or shut it off temporarily. In one instance a casing seat was leaking and it was necessary to squeeze cement up around the pipe for a new seat. A plug of this new type cement was dumped on bottom to protect the low-pressure formation from the entry of cement. The job was successful, and when the plug was drilled out the well came back, producing pipe line oil.

Two sacks of the cement were used as a temporary plug to protect a low-pressure formation in the Norris City field against a pressure of 1700 lb. per sq. in. Another temporary plug in the Storms field of one-half sack of the special cement filling 6 ft. protected the low-pressure formation against a pressure of 1800 lb. per sq. in.

The new cement can often be used to advantage on blowouts. On a recent job in New York State a well was blowing 80,000,000 cu. ft. of gas, and had cratered. There was 450 ft. of surface pipe in the hole, and the bottom of the hole was at a depth of 4500 ft. An attempt was made to kill the well with 1700 sacks of cement, but the cement was blown from the hole. On the second attempt, another 1700 sacks of regular cement was run with 185 sacks of the special cement behind it, and the well was killed.

The characteristics of this new cement make it extremely useful for a limited number of special purposes. The uses outlined above are common to Illinois and have definitely been proved successful where orthodox methods have failed.

P 094.6

Care Should Be Exercised in Cleaning Belts With Steam

THE utmost caution must always be exercised in the use of steam for cleaning belting. Steam is an excellent cleanser for many purposes, but it must be remembered that many kinds of belting cannot withstand the high temperatures that accompany steam. The temperature of steam at atmospheric pressure is 212° F. The higher the steam pressure the higher the corresponding temperature.

These temperatures are excessive for most rubber belting. One prominent rubber belt manufacturer states that his belting is not affected by heat to a temperature of 200° F. He states that when higher temperatures are to be encountered he should first be consulted. That is good advice regardless of the kind of belt. Even when steel chains are used one must be careful in high temperatures or lubrication difficulties will be experienced. Of course steel chains can be cleaned safely with steam.

Balata belting is more sensitive to high temperatures than rubber. Its temperature should be maintained at less than 110° F. At 125° balata gum can be moulded.

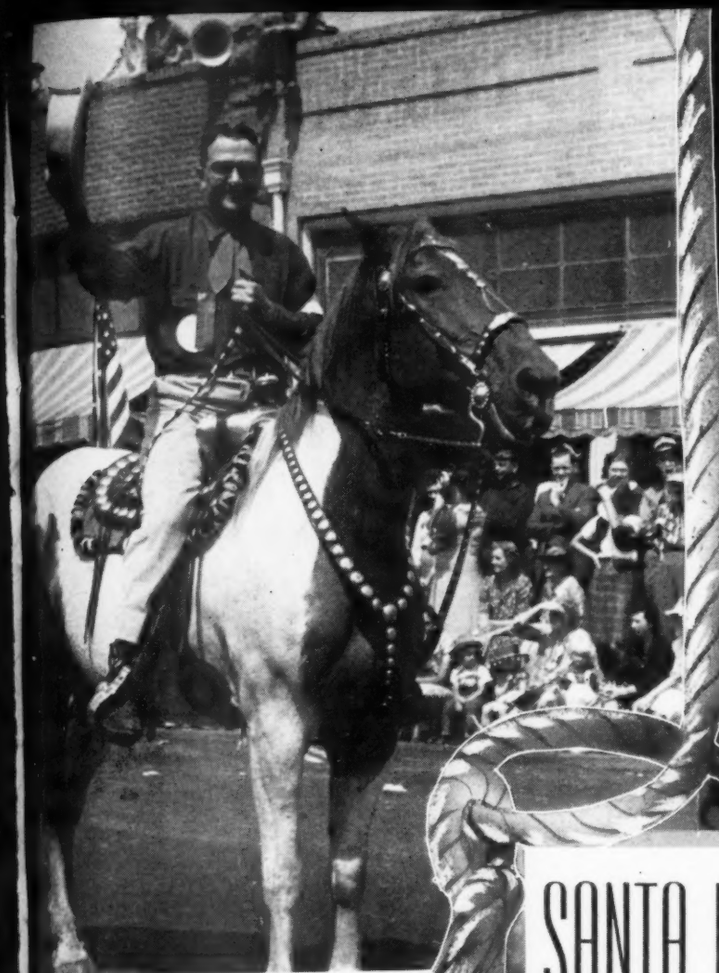
According to one well-known authority on the subject, oak-tanned leather belting should not be subjected to a temperature higher than 115° F., which means, of course, that oak belting should *never* be cleaned with steam. It can't stand it.

Nor should impregnated cotton belting be cleaned with steam because the steam will very likely wash out the impregnating compound. Without the compound, cotton belting does not give satisfactory results. Stitched canvas belting should not be used in temperatures higher than 140° F.

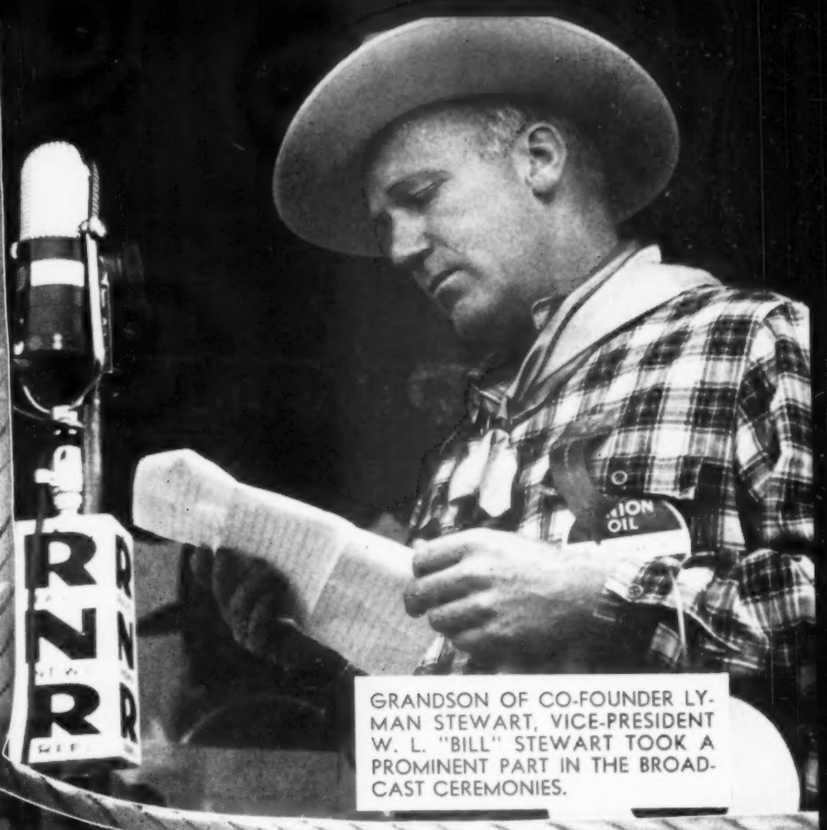
This, then, does not leave many types of belts that can be steam cleaned with safety. As stated in the first sentence, the utmost caution must always be exercised in this connection.

SANTA PAULA *Plays Host to - -* UNION OIL COMPANY

..on occasion of 50th anniversary year



VICE-PRESIDENT A. C. "CY" RUBEL, DONS WESTERN GARB TO LEAD UNION OIL CABALLEROS IN THE FIESTA PARADE.



GRANDSON OF CO-FOUNDER LYMAN STEWART, VICE-PRESIDENT W. L. "BILL" STEWART TOOK A PROMINENT PART IN THE BROADCAST CEREMONIES.

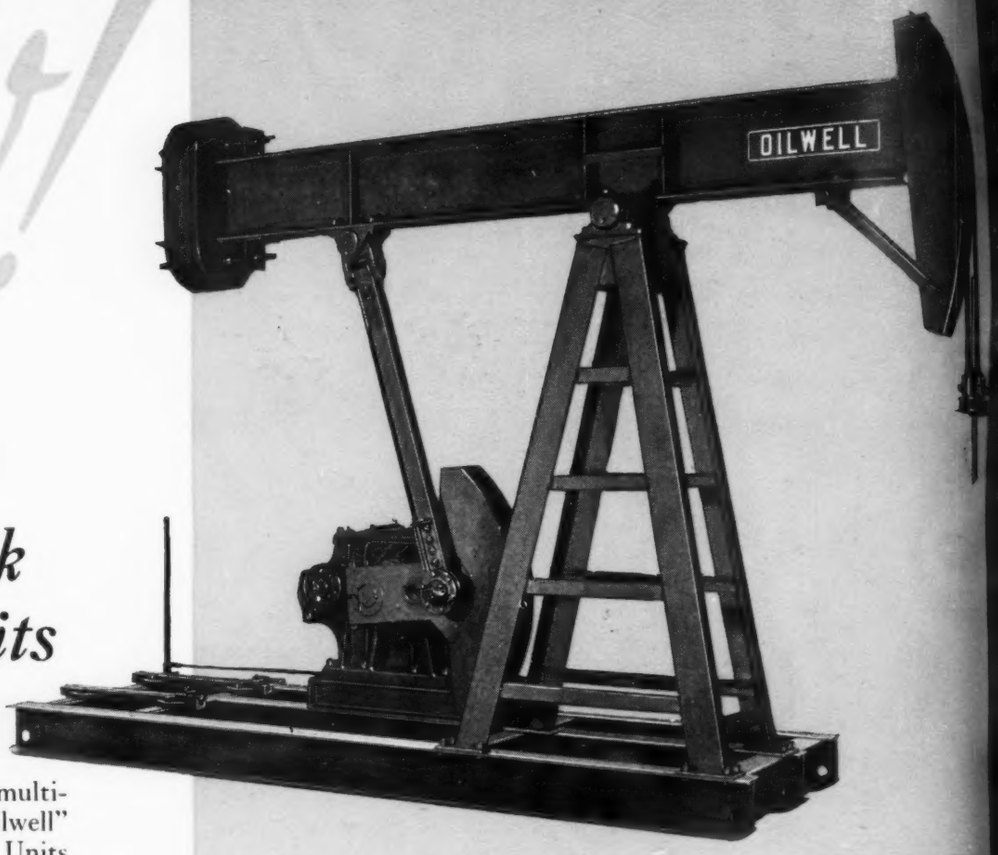
IT IS A PROUD MOMENT FOR MRS. W. W. ORCUTT, WIFE OF OLD TIMER "BILL" ORCUTT, AS SHE CUTS THE FIRST SLICE OF THE 50TH ANNIVERSARY CAKE.

CITY-BRED, CASH BELDON OF THE PERSONNEL DEPARTMENT AND TEAMMATE JEAN CLAY COMPETE IN THE "WILD" COW MILKING CONTEST. NO EXPERT, BELDON LOST TO H. W. SANDERS, COMPANY TREASURER.

FEATURED IN SANTA PAULA'S FIESTA PARADE WAS UNION'S FIRST HORSE-DRAWN TANK WAGON, SHOWN PASSING IN FRONT OF THE COMPANY'S FIRST HOME.

NEW!

"OILWELL" SC-12 and SC-17 *Single-Crank Pumping Units*

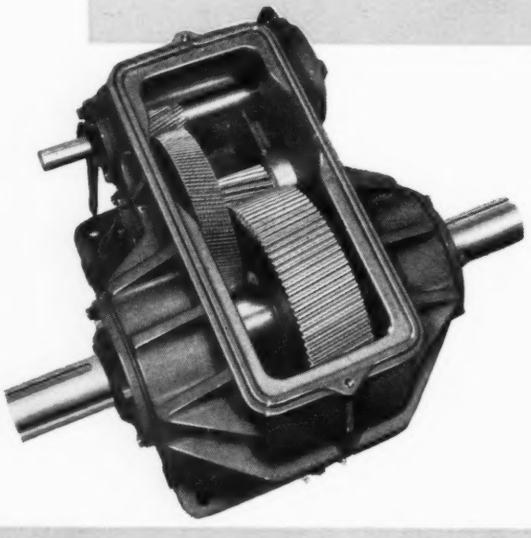


Equally efficient for individual- or multiple-well pumping, the new "Oilwell" SC-12 and SC-17 Single-Crank Units provide both moderate first cost and long-range economy for medium duty service. Here are some of the "plus values" you get in these sturdy new units:

- Skid-type, structural-steel base, short or extended, providing clearance for the crank even when equipped with rotating counterweights.
- Rigid, derrick-type samson post with *machined* top for the *machined* bases of the saddle-bearing housings.
- Changing of stroke lengths made easy by self-aligning, spherical roller bearings on the crank pin and a universal bearing arrangement at the top of the pitman. It is necessary only to remove the crank-pin nut and withdraw the pin — no further dismantling is required.
- All parts of the two units are interchangeable except the crank and the reduction gear.
- Equipped with either an arc hanger or an oilbath, rubber-cushioned link hanger.
- Beam counterbalancing (standard) with an optional rotating counterbalance.

"Oilwell" SC-12 Pumping Unit with extended base.

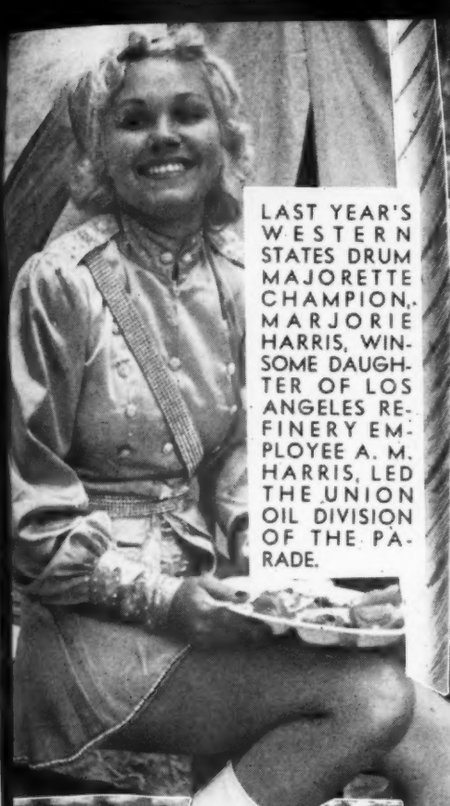
		SC-12	SC-17
Polished-rod load capacity (A.P.I.)	(pounds)	10,000	10,000
Polished-rod strokes	(inches)	22,32,42	22,32,42
Peak torque-capacity at 20 s.p.m. (A.P.I.)	(inch-lbs.)	58,000	82,000
Over-all reduction ratio		31.9:1	32.15:1



TROUBLE-FREE double-reduction gears with precision-hobbed, single-helical gears and pinions represent an important "plus value" in all "Oilwell" Pumping Units. All gears, pinions and shafts are fully heat-treated. Easily-adjusted, heavy-duty, tapered roller bearings are used throughout. Gear cases are rigid semi-steel castings of symmetrical design; and the high- and low-speed shafts are equally extended to facilitate back-crank pumping.

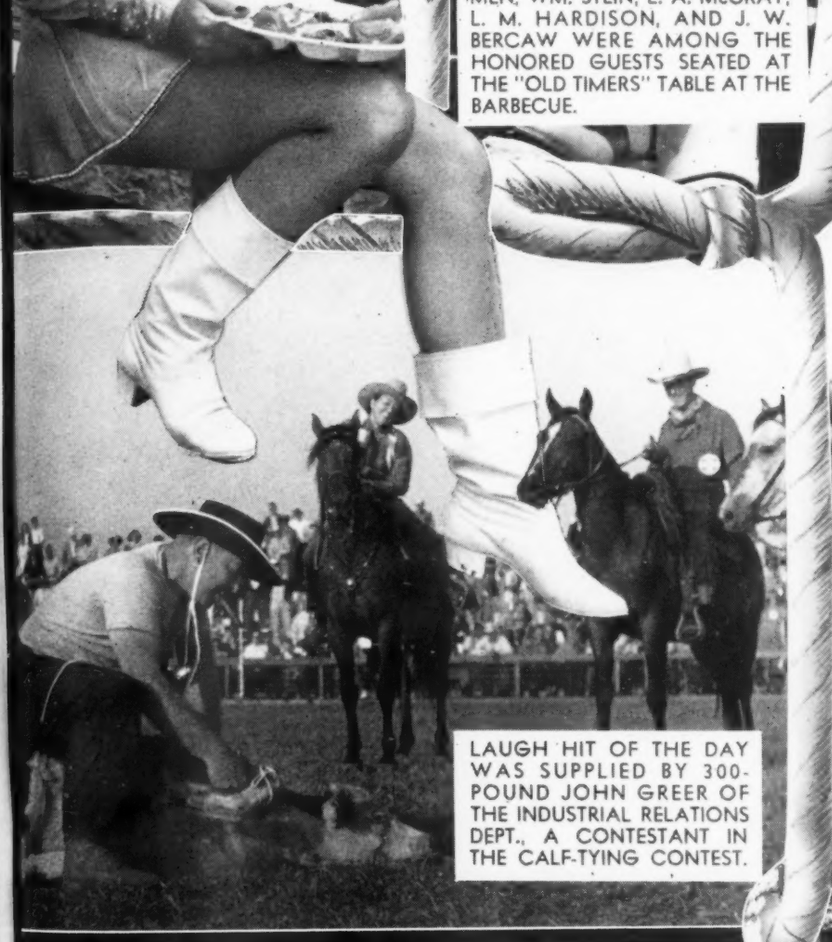
OIL WELL SUPPLY COMPANY

Branch Stores in all Oil Fields
United States Steel Corporation Subsidiary

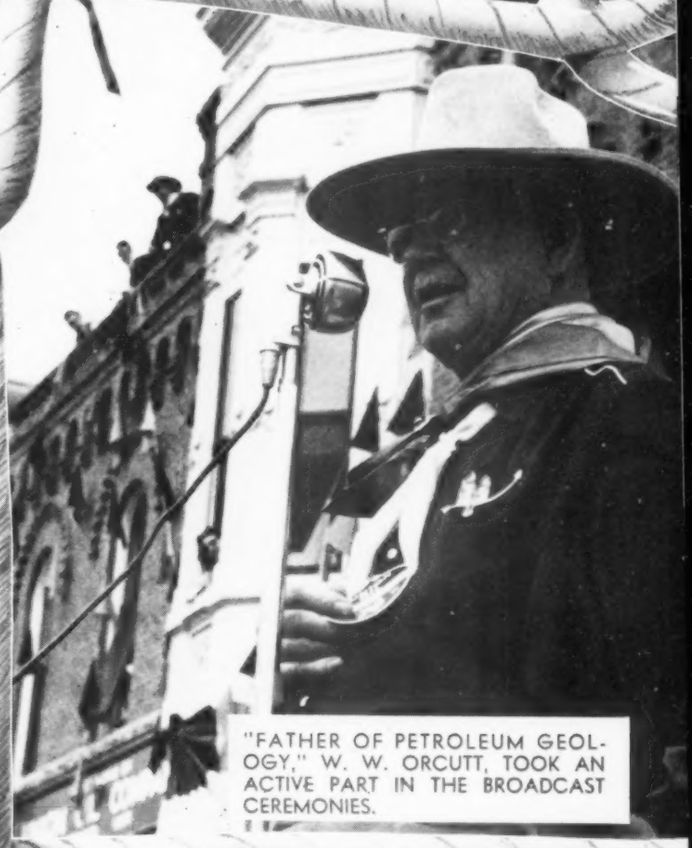


LAST YEAR'S WESTERN STATES DRUM MAJORETTE CHAMPION, MARJORIE HARRIS, WINSOME DAUGHTER OF LOS ANGELES REFINERY EMPLOYEE A. M. HARRIS, LED THE UNION OIL DIVISION OF THE PARADE.

EARLY DAY CALIFORNIA OIL MEN, WM. STEIN, L. A. McCRAY, L. M. HARDISON, AND J. W. BERCAW WERE AMONG THE HONORED GUESTS SEATED AT THE "OLD TIMERS" TABLE AT THE BARBECUE.



LAUGH HIT OF THE DAY WAS SUPPLIED BY 300-POUND JOHN GREER OF THE INDUSTRIAL RELATIONS DEPT., A CONTESTANT IN THE CALF-TYING CONTEST.



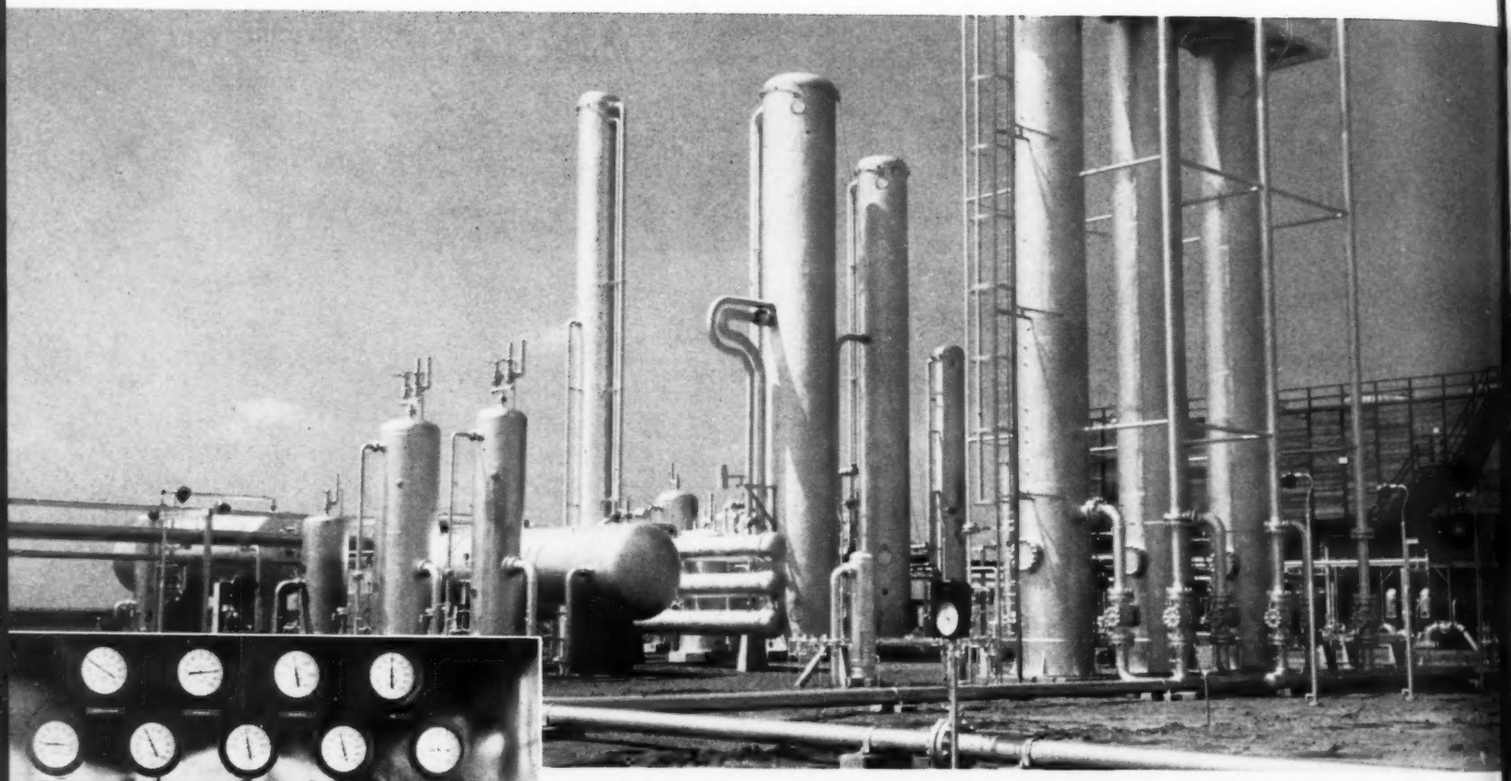
"FATHER OF PETROLEUM GEOLOGY," W. W. ORCUTT, TOOK AN ACTIVE PART IN THE BROADCAST CEREMONIES.

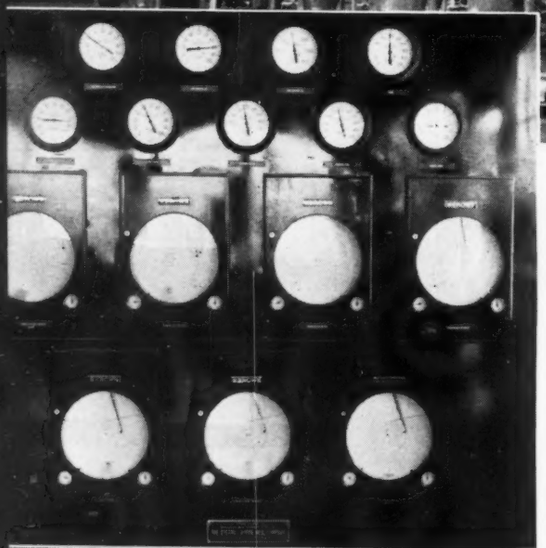
On August 24 the City of Santa Paula, known as the "cradle of the California oil industry," played host to the Union Oil Company on the occasion of the company's 50th anniversary year. Founded in Santa Paula half a century ago by Lyman Stewart and W. L. Hardison, pioneer oil operators from Pennsylvania, Union Oil Company returned to the city of its birth to celebrate officially its 50 years of progress in conjunction with the city's annual Fiesta Ranchera.

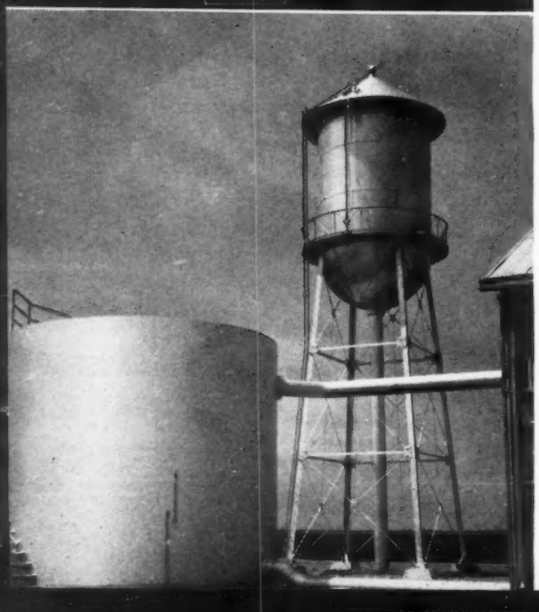
Highlights of the day's activities included the broadcast early in the morning of the city's presentation of a bronze plaque to mark the original home of Union Oil Company. The plaque was presented by Mayor Guy L. Hardison, son of co-founder W. L. Hardison, on behalf of the city to W. L. Stewart, Jr., vice-president of Union Oil Company and grandson of Lyman Stewart. At noon a barbecue was held for an approximate crowd of 5000 employees and their families. Honored guests were old timers who were with the company during the early days in Santa Paula. During the afternoon the City of Santa Paula presented its annual professional rodeo. In addition to having 11 of the country's top-notch rodeo stars, the afternoon show included a number of special Union Oil Company events in which employees participated. In the evening the city played host to the employees at an old time street dance.

LINE FORMS TO THE RIGHT AS APPROXIMATELY 5000 COMPANY EMPLOYEES AND THEIR FAMILIES PARTAKE OF THE NOONDAY BARBECUE.

One Hundred Million Cu. Ft. Recycling Plant Placed in Operation







Above: Processing equipment. Left: Control board. Lower left: Water tanks on jacket-water system

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By FRANK H. LOVE
Managing Editor

COMPLETION of the Gulf Plains Corporation's recycling plant, situated between the Agua Dulce and Stratton fields, Nueces County, Texas, adds an important factor to that high-pressure area's facilities for the recovery of condensate and for reservoir pressure maintenance. This project involved the assembling of a block of approximately 6000 acres and the drilling of a group of wells to depths as great as 6600 ft.

Those behind the undertaking, Robert T. Wilson, Clyde H. Alexander, and John J. Sheerin, were associated in the formation of the Coastal Recycling Corporation, which is operating a large recycling plant north of the Gulf Plains properties. It will be recalled that Messrs. Alexander and Sheerin were members of the group sponsoring The Corpus Christi Corporation, which is operating a plant in the area directly to the south. The relationship existing between these companies has contributed certain operating economies and has permitted a well-ordered plan for the development of the entire Agua Dulce-Stratton area.

Stratton Pipe Line Corporation, owned one-third by each of these com-

panies, has recently been incorporated to take over and operate the system of approximately 50 miles of gasoline line transporting the products of all three plants to the pipe-line terminal at Corpus Christi. This new corporation also owns and operates 450,000 bbl. of tankage, including that now under construction.

The Gulf Plains installation has a capacity of 100,000,000 cu. ft. of gas per day and is designed to operate at an intake pressure as high as 1500 lb. per sq. in. gauge and a discharge pressure as great as 3250 lb. per sq. in. Separate gathering systems are maintained for supply wells located in the north and south sections of the block, the plant being centrally situated. When the drilling program is completed, the company will have approximately 25 producing wells connected to its plant but, as many of these will be double completions, the effect on sand conditions will be the equivalent of more than 40 wells. Engineering studies have shown that this number of wells will keep dilution at an absolute minimum and will prohibit any possibility of excessive formation pressure differentials with subsequent channeling. There will be ten producing wells in the north area connected to the plant and 15 in the south. Intake pressure of the south system is 1350 lb. and discharge pressure to key wells is 3250 lb., whereas on the north system the intake pressure is 1250 lb. and the discharge pressure 2500 lb.

Among features of the plant are: (1) use of 2-cycle gas engines to drive the generators; (2) use of vertical pumps for circulating water over the cooling tower; (3) direct-fired rich oil heaters; (4) induced-draft type cooling tower; (5) high-pressure absorption; (6) extensive use of electric power, and (7) 2-zone producing and injection wells.

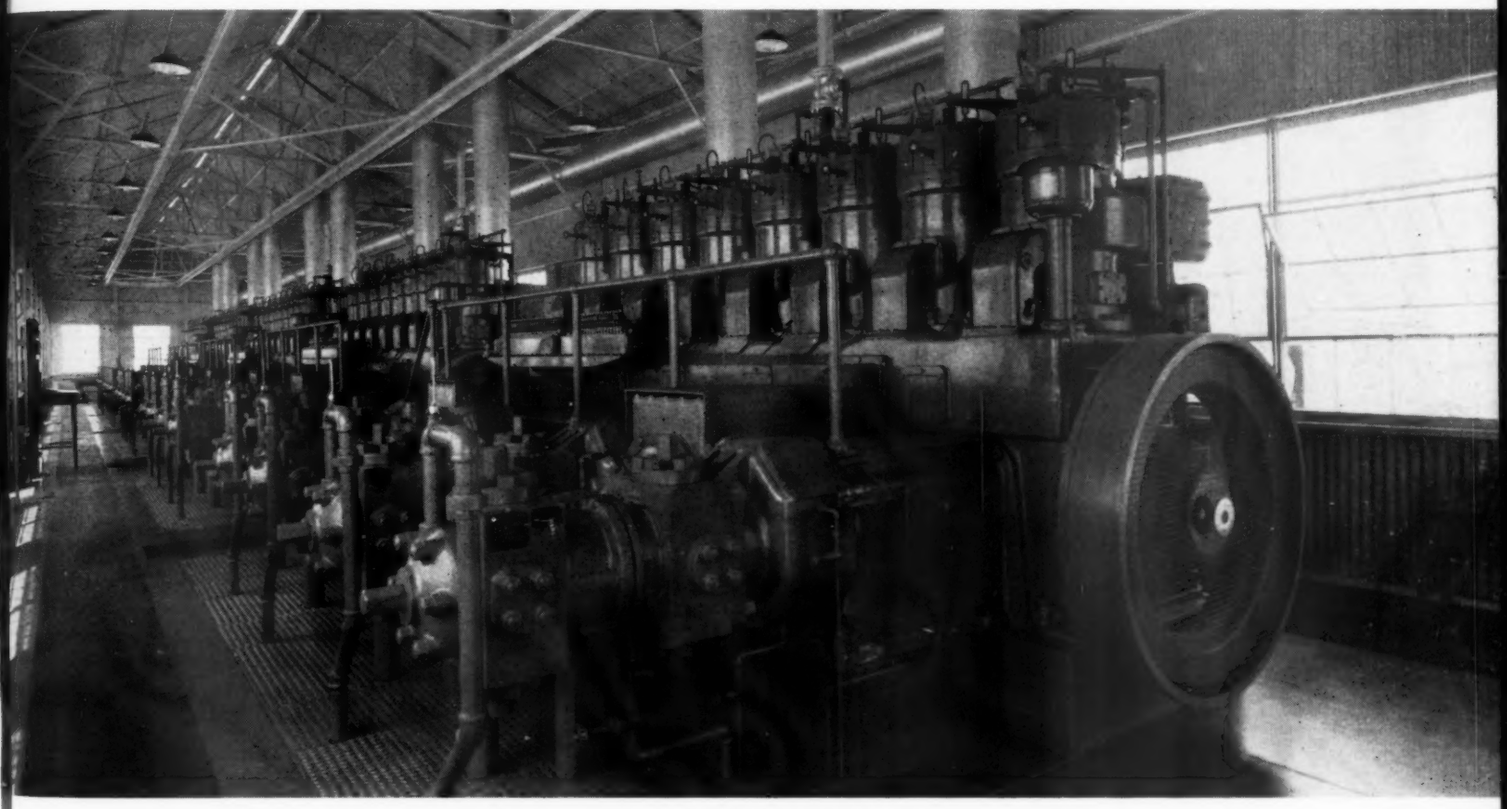
Wet gas is metered at the plant and, because the temperature is too great for satisfactory processing, is led directly through cooling sections in the base of the cooling tower before being sent to the high-pressure absorbers, of which there are three. The operating pressure of the absorbers when handling gas from the south system is 1350 lb. and when handling gas from the north system is 1250 lb.

The absorbers each contain 20 bubble-cap plates and a scrubber that is mounted in the upper section, the latter being designed to reduce mist carryover. The denuded gas upon leaving the absorbers goes directly to the suction of the compressor units for injection into the key wells.

The rich oil is discharged from the base of the absorbers to the high-pressure vent tank upon which is maintained a pressure of 600 lb., to the intermediate vent tank upon which the pressure is 300 lb., thence to the low-pressure vent tank upon which the pressure is 150 lb. These three stages of pressure reduction result in minimum loss of the more valuable hydrocarbons.

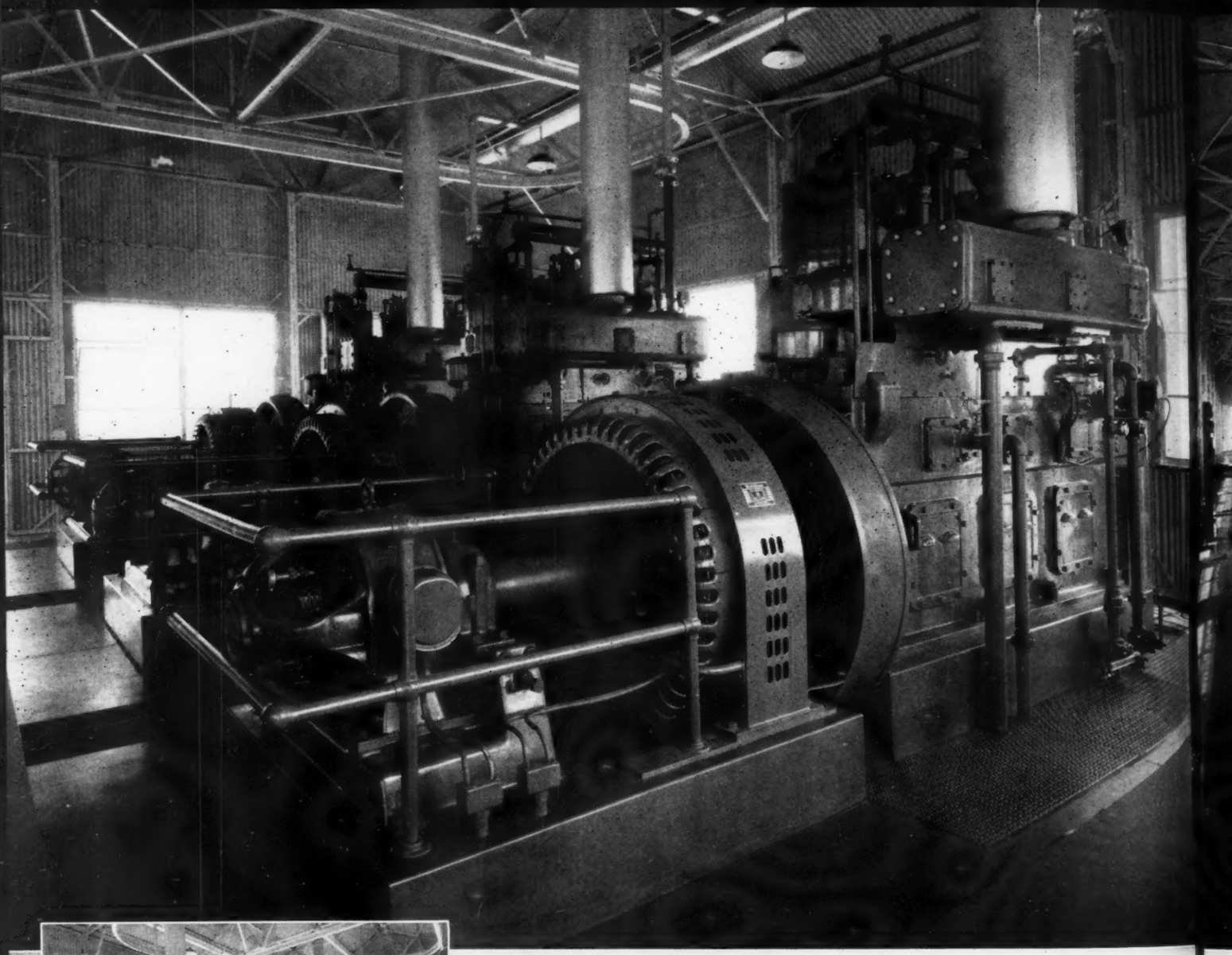
From the low-pressure vent tank the rich oil passes through heat exchangers and into the rich-oil flash separator. From this flash tank the vapors separated by heating in the heat exchangers are discharged directly to the high-

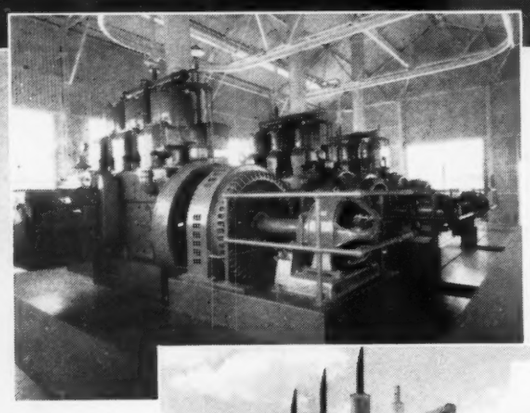
(*Continued on Page 98-d*)

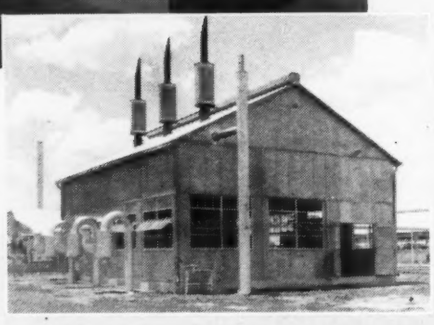


Compressor ends of the five 800-hp. compressors

ANOTHER BIG CLARK







Photographs show two views of battery of generator units totalling 1200 H.P. and building in which this auxiliary plant is located.

FIRST 2-Cycle, Direct Drive Generator Units

THESE CLARK "Angle" supercharged 3-cylinder 400 H.P. engines represent the first 2-cycle engines to be used for direct driving of generators. The installation—in the Gulf Plains Recycling plant—is proving highly efficient. These engines are equipped with special fly wheels, also hydraulic governors which proportion air and gas by automatically controlling the scavenger air. Thus they can be operated in parallel at constant speed with variable loads. The generators are 3-phase, 60-cycle, 440 volts.

CLARK "Angles" answer every compressor requirement. Consult with our nearest office.

CLARK BROS. CO., INC., Olean, New York, U.S.A. Export Offices: 30 Rockefeller Plaza, New York. Foreign Offices: 72 Turnmill St., E. C. 1, London; 4 Str. General Poetas, Bucharest, Roumania.

CLA

RECYCLING PLANT !

4000 H. P. of CLARK Super-2-Cycle "Angles"

THIS 4,000 H.P. battery of CLARK "Angle" Compressors, in the Gulf Plains Recycling plant, at Banquete, Texas, offers another proof of CLARK leadership in the recycling field. CLARK "Angle" recycling plants include one 7,200 H.P. plant under construction (world's largest), two 4,000 H.P., a 3,000 H.P. and many smaller plants in operation. The Gulf Plains plant is unique in that it is so arranged that it can operate on two different suction pressures, taking full advantage of well pressures. It is handling 130,000,000 cu. ft. of gas daily at suction pressures of 1200 and 1500 lbs., returning the gas to the wells at 2800 lbs.

Photographs show front and rear view of the battery of 5 CLARK 800 H.P. "Angles" in main plant, and building in which it is housed.

ARK

Domestic Sales Offices and Warehouses: Tulsa, Okla.; Houston, Texas; Chicago, Ill.; Boston, Mass. (131 Clarendon St.) West Coast Offices: Smith Booth Usher Co., Los Angeles, Calif.

(*Continued from Page 98-a*)

pressure gasoline still. They do not pass through the direct-fired oil heaters as does the rich oil. The rich oil is passed to the heaters where the temperature is raised to 580°F., the operating temperature required by the high-pressure still. In the high-pressure still, which is operated at a pressure of 35 lb., the rich oil is fractionated, together with the gases previously separated in the rich-oil flash separator. The overhead product is a motor fuel of 395 end-point, 66-67 gravity, and 9.5 vapor pressure. The bottom product is a mixture of absorption oil and distillate and this is flashed to the kerosine still, operated at atmospheric pressure, and the kerosine cut removed overhead.

The lean oil is then picked up by the hot-oil pump, which discharges through the oil exchangers to the absorption-oil coolers situated in the base of the cooling tower, the high-pressure oil pumps forcing it into the absorbers. Gasoline vapors from the high-pressure still are condensed in cooling sections in the cooling tower, pass to an accumulator, and thence to the stabilizing column. The accumulator also functions as a dewatering tank and separator for the uncondensable vapors. Water is discharged from the accumulator and the vapors are compressed and injected into the stabilizing column. Stabilized gasoline is discharged through an exchanger and an aftercooler before going to storage.

After removal of the kerosine from the atmospheric still, the product passes through condensers to an accumulator, thence to storage. Except for a 500-bbl. kerosine storage tank at the plant all storage is at a tank farm about 4 miles distant. Stabilizer pressure boosts the gasoline to storage through a 4-in. line and from here it is pumped to Corpus Christi by two 4½ by 10 pumps driven through a V-belt by two 125-hp. gas engines.

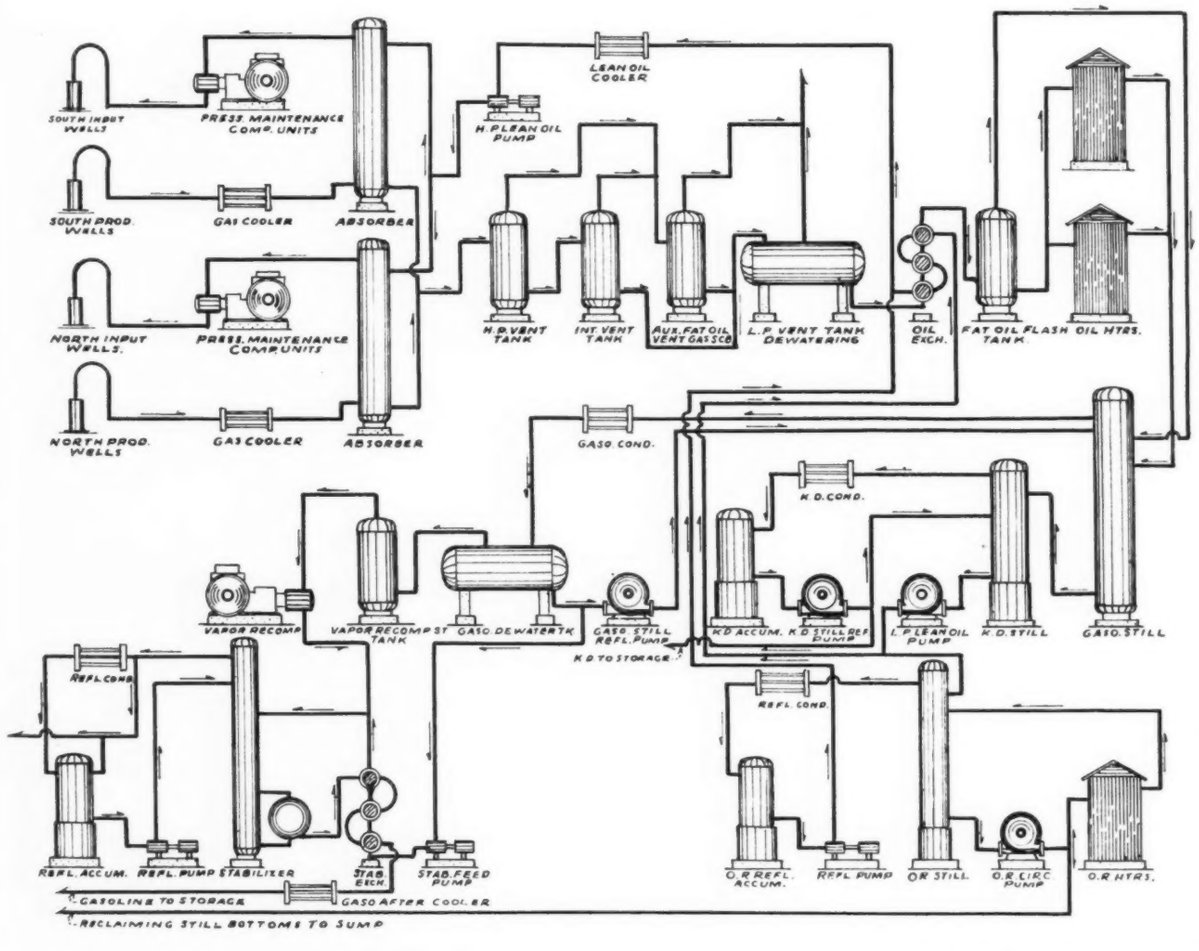
Pressure Maintenance

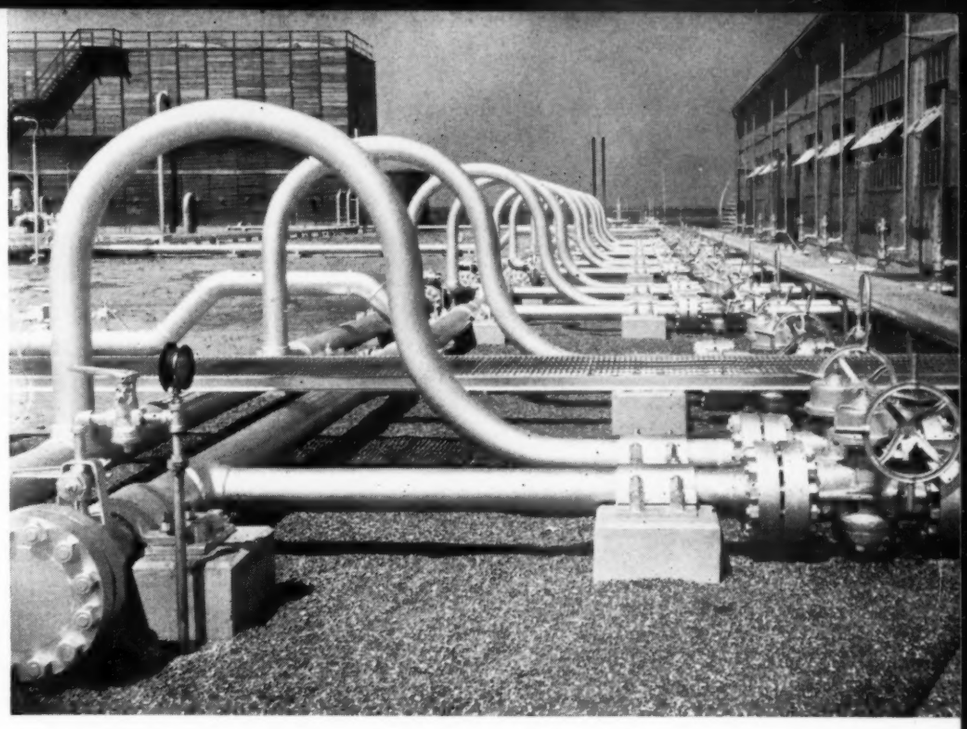
For returning the dry gas to the producing sands for pressure maintenance there are five 800-hp., 2-cycle, 8-cylinder, right-angle, gas-engine-driven compressors. One unit is equipped with a 11½ by 14 recompressor cylinder and three 4⅜ by 14 cylinders. Two of the units have 3⅝ by 14 cylinders and the two remaining, 4⅜ by 14 cylinders.

Compressor cylinders are of forged-steel construction designed to operate

(*Continued on Page 101*)

Flow sheet of Gulf Plains Corporation's recycling plant





Aboveground manifold of compressor lines

(*Continued from Page 98-d*)

at a maximum pressure of 4000 lb. per sq. in. The removable liners in the cylinders are of cast-iron. The cylinder barrel is encircled by a cast-iron case that serves as a water jacket.

The power ends of the compressor units consist of a single row of cylinders in a vertical position that operate on the 2-cycle principle.

Bearings are lubricated under pressure and a force-feed lubricator pumps oil to the power cylinders, to the compressor and scavenging cylinders, and to the metallic packing on the compressor piston rod. The same oil that lubricates the engine pistons also serves as a cooling medium.

Each compressor is equipped with an air cleaner of the oil-bath type, which has a maximum capacity of 5000 cu. ft. of air per minute.

Gas is returned to the producing zones through five key wells. The south system has three single-input wells, at depths of 4800 ft., 6200 ft., and 6400 ft. There are two key wells in the north system, one of which is a double-input well, gas being injected to a 4800-ft. zone and a 5000-ft. zone. The method adopted to return the gas to two zones in the same well has been to pack-off the 4½-in. casing and inject the gas through the tubing to the lower sand and through the annular space to the upper sand. The single-injection well in the north system has a depth of 6600 ft. Injection of gas into this type well is principally through the annular space, but partly through the tubing.

Cooling Tower

The induced-draft type cooling tower has a capacity of 7200 gal. per min. The tower is constructed of redwood and the collecting basin is divided into sections. Each section has a cast-iron redistribution spray system and flapper valve above the cooling coils, making it possible to take individual sections out of service when necessary. Six 138-in. fans are situated at the top of the tower, driven by 25-hp., splash-proof motors.

A departure has been made in the conventional manner of circulating water over the top of the cooling tower. Instead of the usual type of water-circulating pump, two vertical propeller pumps are employed. These are mounted at the side of the tower, the pumps taking suction from a sump in the tower basin, and discharging over the top. The units are in the open, having no housing whatsoever. Each pump is driven by a 50-hp., weatherproof motor and has a capacity of 3600 gal. per min.

Generating Equipment

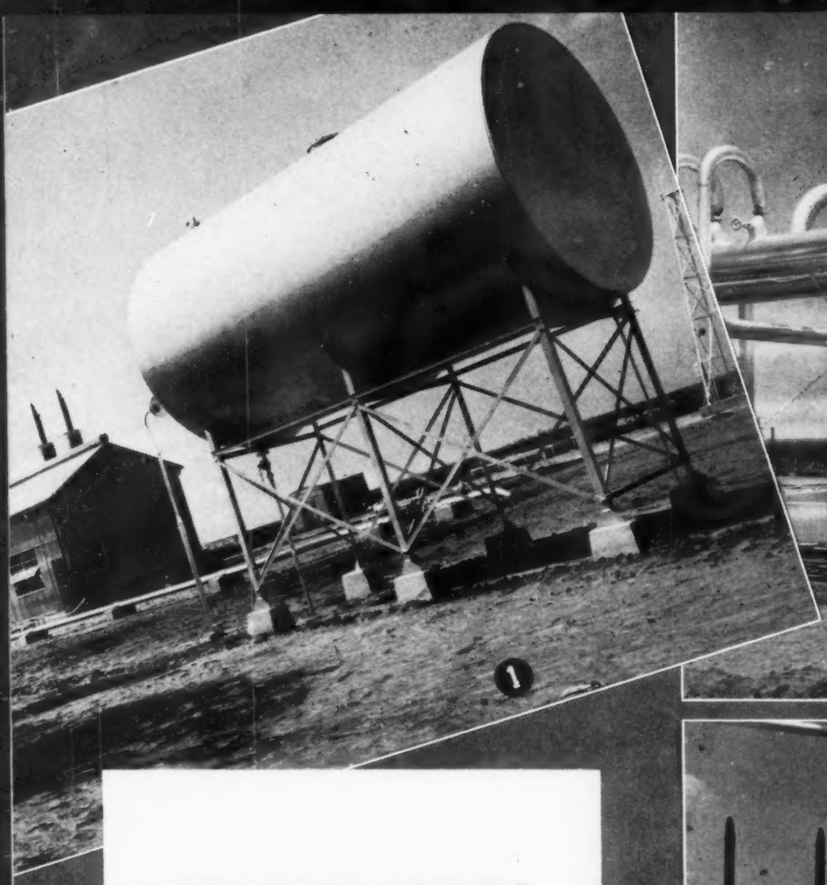
The company is using three 2-cycle supercharged engines to drive its generating equipment. This installation is unusual in that 2-cycle gas engines are used to drive a-c. generators, a practice uncommon where constant potential must be maintained or where two or more generators must operate in parallel despite wide fluctuations in generator loads.

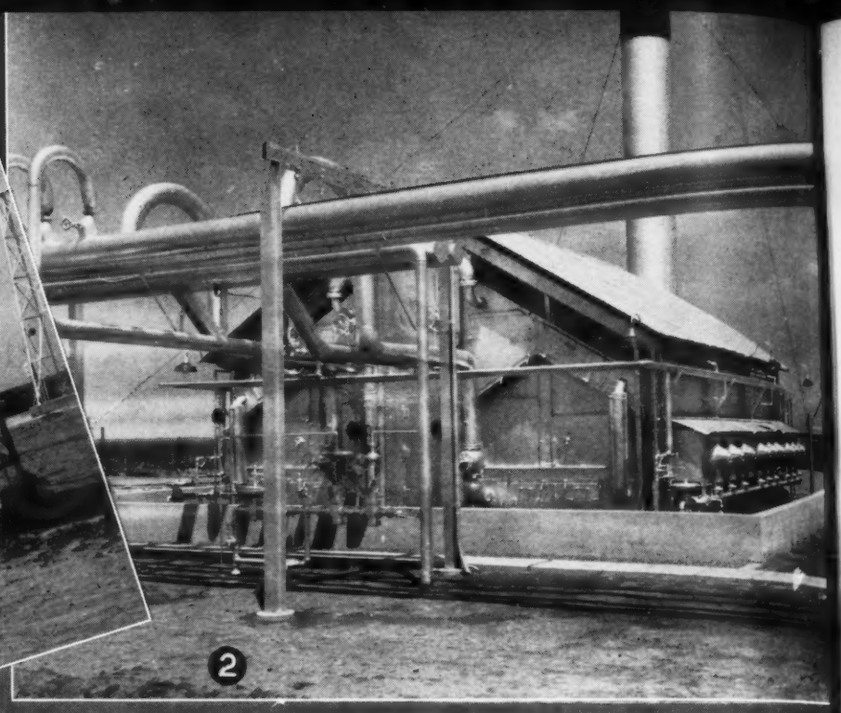
For satisfactory service constant speed is essential over a wide load range. Although gas engines employing the 2-cycle principle have proved efficient and economical when full-load, continuous-heavy-duty performance is required, it is generally conceded that they are unsuitable when very close regulation is necessary. At partial loads 2-cycle engines have a tendency to misfire and "hunt" due chiefly to the improper mixture of air and fuel. This detrimental feature has been eliminated by the development of the scavenging air by-pass control, and it is now possible to obtain 4-cycle performance with the 2-cycle engine for services requiring close regulation.

Each of the gas engines at the Gulf Plains installation has three 14-in. bore by 14-in. stroke vertical power cylinders and is rated 375-b.hp. at a speed of 360 r.p.m. Each engine is direct-connected to a 312-kva., 80 percent power factor, 360-r.p.m., 480-volt, 375-amp., 3-phase, 60-cycle, synchronous generator with a 7.5-kw., 125-volt, 360-r.p.m. direct-connected exciter.

The engine proper consists of a single row of three single-acting supercharged power cylinders and a horizontal double-acting scavenging cylinder. The scavenging cylinder pumps air at approximately 3¾ lb. per sq. in. pressure into a common manifold built in the upper crankcase. Each power cylinder is supplied from this manifold.

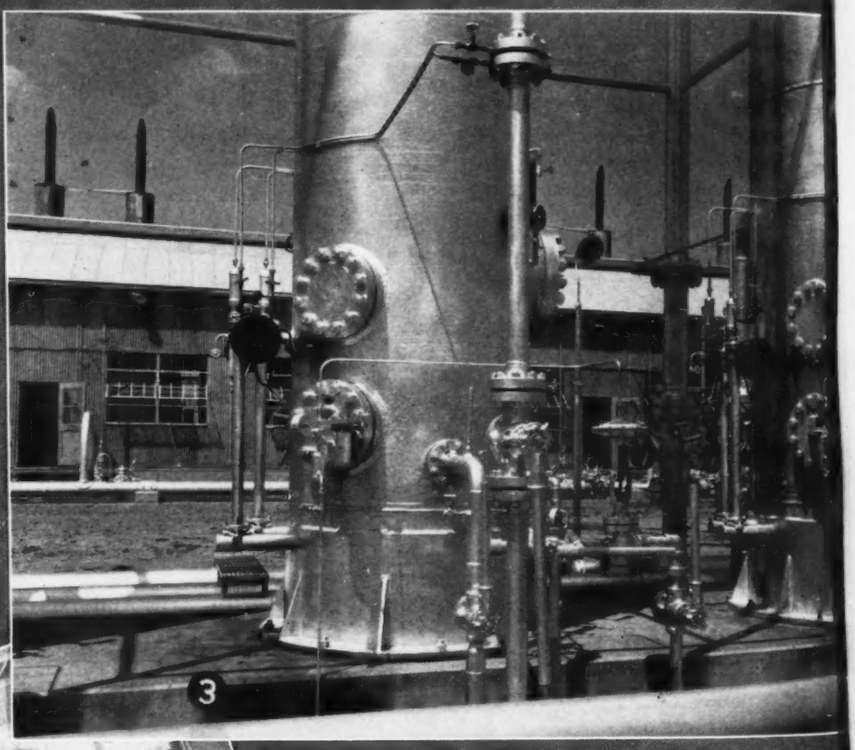
The supercharged power cylinder has been designed for what is known as high velocity or forced water cooling. A spiral has been cast integral with the cylinder that forces the cooling water to flow around the cylinder wall. Water enters the cylinder below the exhaust port, circulates through the cylinder, then enters the spiral chamber from whence it travels around the cylinder at a high velocity until it reaches the upper flange. From the

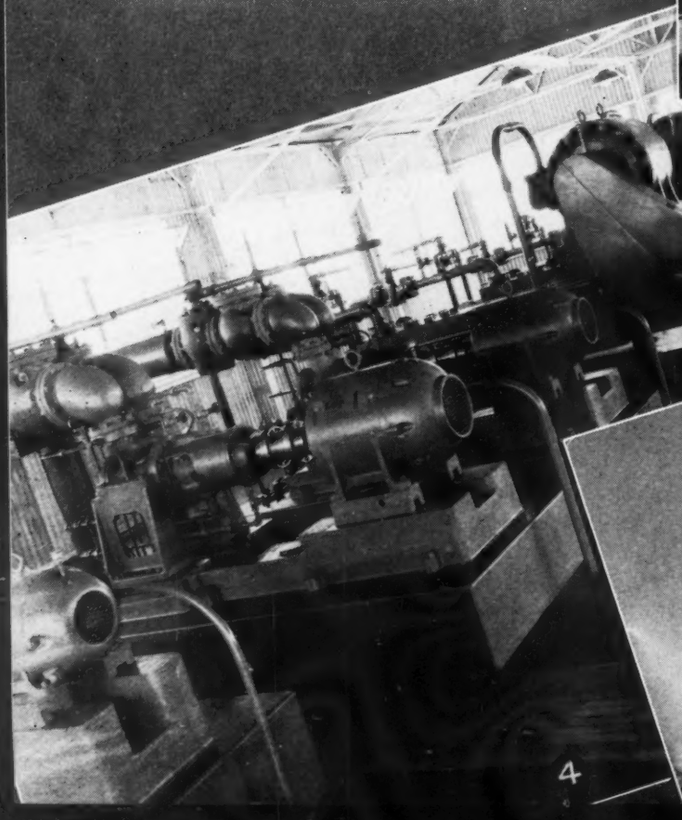




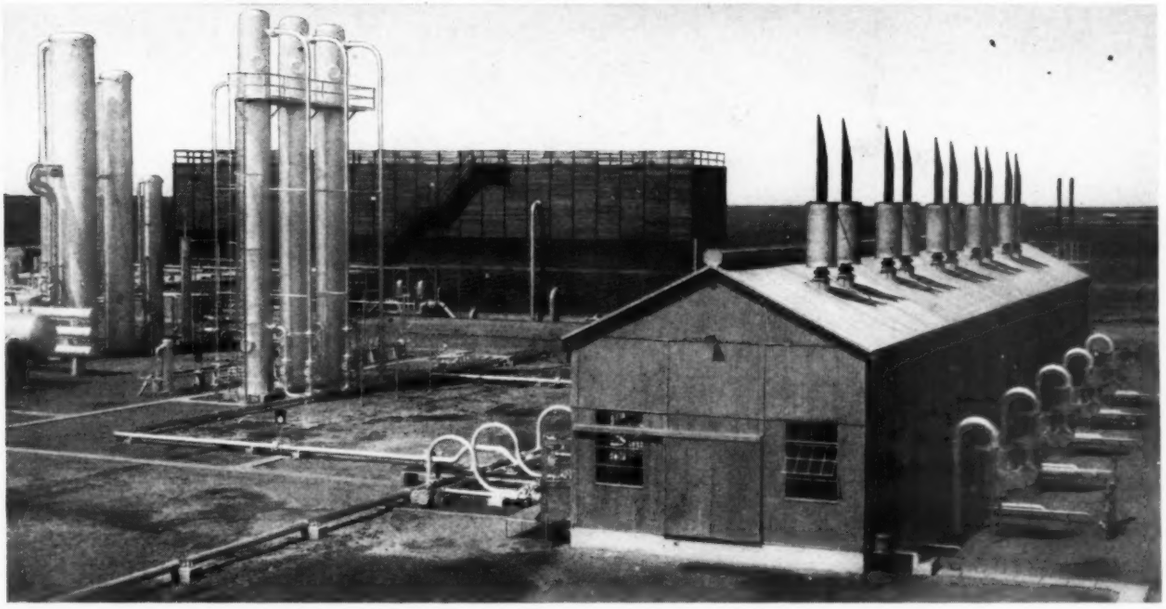
GULF PLAINS CORPORATION RECYCLING PLANT

1. Lubricating oil storage tank.
2. Direct-fired absorption-oil heaters.
3. Flow meters on absorbers.
4. A part of the processing pumps.
5. Induced-draft cooling tower.





100,000,000 cu. ft. per day Distillate Recovery and Pressure Maintenance Plant



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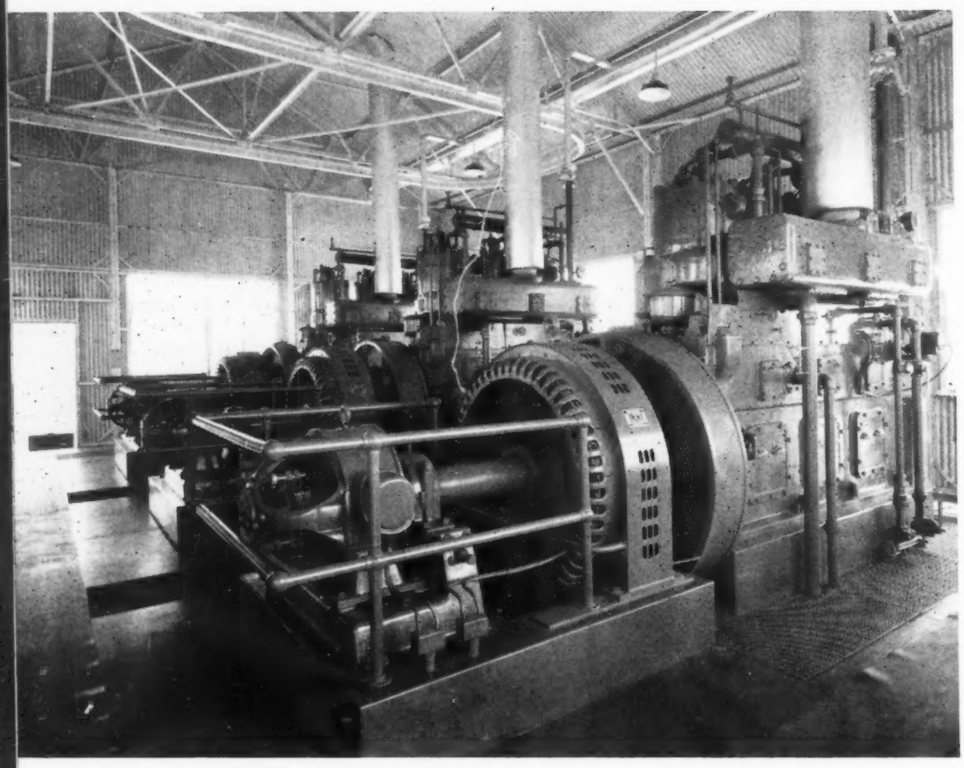


Three 2-cycle supercharged gas engines drive the a-c. generators

upper flange it is carried to the cylinder head where it again circulates in the spiral passage, providing forced cooling around the upper spark plug opening and fuel injection port, finally leaving through the outlet pipe on top of the cylinder head. The head proper consists of a steel casting with a plate bolted on top. This construction permits proper cleaning of the cores when the casting is made and complete examination of all the passages after it has been in operation. The outer cover of the head consists of a cast-iron jacket that holds the steel plate in place. The power cylinder barrel has two rows of air intake ports, one above the other. The upper row is controlled by strip valves that prevent the exhaust gas from entering the air intake passage as this port is uncovered slightly before the exhaust port opens on the downward stroke of the piston.

The supercharged right-angle gas engine operates on the "super 2-cycle" principle that is essentially a modification of the well-known two-stroke cycle. The sequence of operation includes the necessary phases of inlet, compression, ignition, and exhaust, with several important changes. Beginning at the end of the power stroke, the operation is as follows:

1. The charge has been ignited, has expanded, and the power piston is approaching the end of its stroke.

2. As the piston approaches bottom center, it uncovers a series of exhaust ports, allowing the hot, spent gas to escape, and dropping the pressure to approximately atmospheric. At this time the piston has uncovered the first row of valve-controlled intake ports and has begun to uncover the second row of scavenging air inlet ports.

3. As the scavenging cylinder is double acting, has considerable excess capacity (50 percent), and pumps into a large header, the pressure in the manifold need be only approximately 3¾ lb. when the second row of ports open. The air rushes upward into the cylinder, striking the deflector head on the piston, which in turn directs the air flow straight upward into the cylinder head. Because the aid sweeps all parts of the combustion space before entering the exhaust manifold, thorough scavenging and charging of the cylinder results.

4. The piston reaches bottom center and starts the upward stroke, closing the first row of intake ports and then the exhaust ports in succession. The second row of valve-controlled intake ports is still open and air continues to enter the cylinder until these ports are closed by the piston in its upward travel. The pressure in the cylinder at this point is approximately that of the scavenging air, which is 3¾ lb. per sq. in. Air admitted through the second row of valve-controlled intake ports at this pressure may be considered as being supercharged. Compression begins when the ports are completely closed.

5. As the power piston starts upward, the fuel gas injection valve in the cylinder head begins to open and admits fuel gas at a pressure of 12-15 lb. per sq. in. The timing of this valve is so arranged that none of the gas is wasted through the exhaust ports. This method of scavenging and fuel control accompanied by effective mixing of the gas and air in the cylinder accounts for the high thermal efficiency of the engines.

6. Compression of the fuel gas and air mixture continues until ignition completes the cycle.

The development of the scavenging air by-pass control enables the engines to maintain economical performance throughout the load range of the engine. The by-pass valve automatically controls the flow of scavenging air to the cylinders to maintain a correct mixture of fuel gas and air for the entire load range. The by-pass valve is operated by a diaphragm motor that is actuated by the variation in pressure of the fuel gas as it is delivered to the injection valves by the governor valve. As the load on the engine is reduced, the governor closes the governor valve to reduce the flow of fuel gas. The pressure of the gas on the discharge side of the governor valve then is lowered. As the diaphragm of the motor is actuated by the fuel gas, the force on the diaphragm is reduced and the stem of the diaphragm motor is raised by the motor spring. The stem operates the linkage of the by-pass valve to open the valve and bleed-off a portion of the scavenging air. Hence, the volume of air that is passed to the cylinder is reduced sufficiently to maintain a correct gas and air mixture. Similarly, as the load on the engine is

increased, the governor opens the governor valve to increase the flow of fuel gas. The pressure of the gas on the discharge side of the governor valve is then raised. The force on the diaphragm of the motor is increased to overcome the spring force and lower the stem of the diaphragm motor. The stem operates the linkage of the bypass valve to close the valve and increase the volume of air that is delivered to the cylinders.

Absorption Oil Reclamation

Absorption oil is maintained in proper condition by diverting a side stream of the hot oil from the discharge of the hot lean-oil pump to an oil-purification still. Oil is circulated from the lower part of the still through a small direct-fired oil heater. Fractionation takes place in the still and an overhead product is obtained. This product is condensed and returned to the absorption-oil system at a point just before the oil enters the lean-oil coolers in the cooling tower. In this manner the lean oil is cleaned and adjusted for endpoint and molecular weight. Heavy ends removed from the absorption oil in the reclaiming still, as well as all foreign material, are disposed of in a burning pit.

Steam Plant

Steam utilized in the operation of the plant is generated by three 125-hp. oilfield type boilers operated at a pressure of 250 lb. Each boiler is equipped with four intermediate pressure burners, water gauge column, high and low level alarm, and feedwater regulator. Boiler-feed pumps consist of two 7½ by 4½ by 10 pumps, steam-driven. Steam lines are insulated and carried overhead.

Pumping Equipment

Both motor-driven and steam pumps are used in the various plant services. The following is a list of the types of equipment and their duties:

Oil-reclaiming pump to system—a 3½ by 3½ by 4 pump, steam driven.

Oil-reclaiming circulating pump—a 3460 r.p.m. centrifugal pump driven by a 3-hp. motor.

Hot-oil pumps—two 3510 r.p.m. centrifugal pumps direct-connected to 25-hp. motors. Each has a capacity of 300 gal. per min.

High-pressure lean-oil pumps—two 2¾ by 10 pumps driven by 75-hp. motors, each having a capacity of 65 gal. per min., and a 2¾ by 12 pump driven by a 100-hp. motor and having a capacity of 85 gal. per min.

Stabilizer reflux pump—a 12 by 8½ by 18 steam pump.

Stabilizer feed pump—a 12 by 7 by 18 steam pump.

Stabilizer reflux and feed pump (spare)—a 12 by 8½ by 18 steam pump.

Distillation unit utility pump—a 6 by 4 by 6 steam pump.

Gasoline reflux pumps—two centrifugal pumps, 3450 r.p.m., driven by 7.5-hp. motors.

Kerosine distillate reflux pumps—two centrifugal pumps, 3500 r.p.m., driven by 2-hp. motors.

Yard utility pumps—two 6 by 4 by 6 steam pumps.

Kerosine shipping pump—a 3 by 4 piston pump driven by a 5-hp. motor.

Boiler-feed pumps—two 7½ by 4½ by 10 steam pumps.

Jacket water pumps—two centrifugal pumps, 1770 r.p.m., driven by 75-hp. motors.

Shipping pumps—two 4½ by 10 pumps, one driven by a 125-hp. motor and the other by a gas engine.

Cooling tower circulating water pumps—two vertical propeller pumps driven by 50-hp. motors.

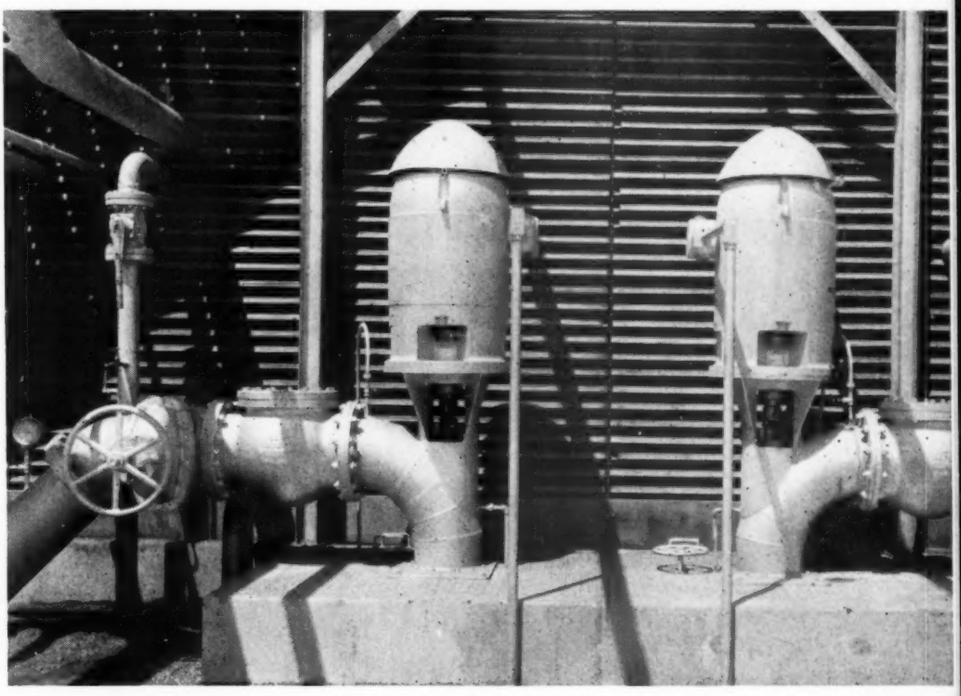
Producing Wells

Wells in the north area are producing from the following depths: 4800 ft. (Comstock sand), 5000 ft., 5500 ft. (Driscoll sand), 6200 ft., and 6600 ft. Wells in the south area are producing from the following depths: 4800 ft. (Comstock sand), 6200 ft., and 6400 ft.

Two of the wells are double completions. Elliff B-1 is producing both from the 4800-ft. and 5000-ft. zones, and Butts No. 3 is producing from depths of 6200 ft. and 6400 ft.

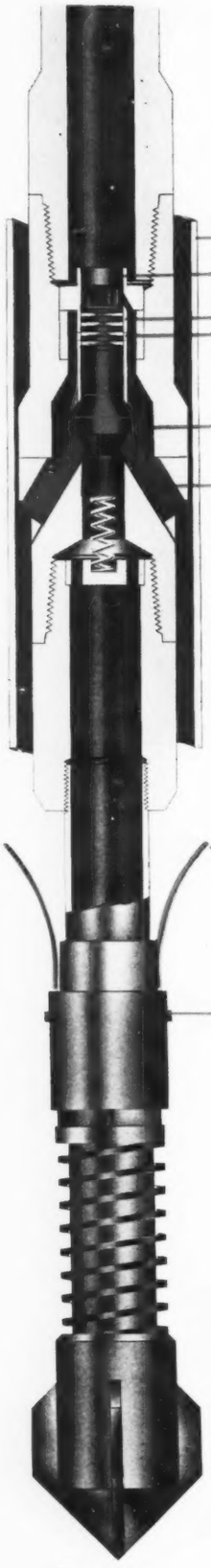
To flow them, the wells are packed-off immediately above the bottom perforations. Above the packer is an intermitter by means of which the wells are flowed 6 hours through casing and 6 hours through tubing. This arrangement prevents fluid at the bottom of the casing from congesting the well.

The plant was designed and constructed on a turnkey basis by The Stearns-Roger Manufacturing Company of Denver, Colorado, and their associates, Parkhill-Wade of Los Angeles, California.



Vertical propeller pumps for pumping water over the cooling tower are among the plant's features

BARRETT & ROBISHAW
EXPANDING CASING MILL



Expanding Cutting-Thru Mill

COMPLETELY MILLS AWAY ENTIRE CASING WALL

SEE ARTICLE, PAGES 107-108

Operators have proven the following uses and advantages in using the expanding mill:

1. Removing an entire section of casing before setting whipstock eliminates the hazards of old style whipstocking and the problem of drilling tools hanging when passing through irregular windows as in the old type side window.

2. Removing casing for shooting the sand in open hole with nitro-glycerine.

3. Acidizing sands in open hole after removing section of casing.

4. Setting screen against the sand section, eliminating pipe perforating especially in cases where the sand has a low bottom hole pressure or produces low gravity oil.

5. Removing casing for gravel packing sand section in open hole and setting screen.

6. Squeezing cement in open hole to obtain shut off of gas or water in the sand.

7. Whipstocking out of the casing above the liner or screen to eliminate time and the hazards of pulling packers, liners or screen and setting screen in another section of the same sand.

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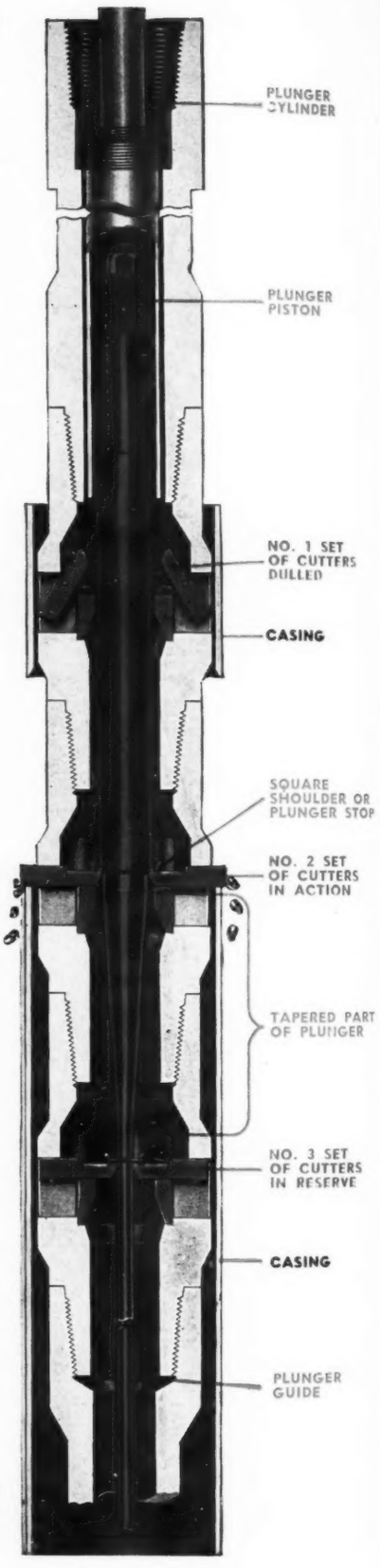


Expanding Mill With Self Changing Cutters

Casing Cutting Tool May Stimulate Exploitation of Cased-Off Sands In Older Fields

PETROLEUM ENGINEER EXCLUSIVE FEATURE

Milling device completely removes steel casing when access for shooting sand is desired — gamma ray and sampling tool will help locate and test favorable strata behind casing

Clarence Morris Dies

As the last pages of *The Petroleum Engineer* were being put on the presses, word was received that Clarence Morris, president and general manager of The Petroleum Engineer Publishing Company, had passed away in Los Angeles, California. Death came to this prominent figure in the oil industry on Wednesday, September 18, as the result of a heart attack.

By H. LEE FLOOD
Associate Editor

SPEAKING in general terms for a moment, there are two topics that never fail to provoke a certain amount of comment and conjecture when oil men get together. One of these concerns the amount of oil and the number of new fields yet to be discovered and the other has to do with ways and means by which still more oil can be recovered from known fields and, more specifically, from the older fields drilled before present-day methods of logging and testing potential producing formations had been developed.

It would be difficult to estimate the amount of oil that might be recovered from upper formations that have been cased-off in the thousands of wells drilled in older fields. As a matter of fact, there has been little occasion to give much thought until recently to the possibility of exploiting such cased-off production because there have been no methods available by which access could be gained readily through the casing string when considerable area of the sand face needed to be exposed. More important, the greatest deterrent to such efforts has been, of course, the inability to detect, through casing, formations worth testing.

It has been extremely interesting during recent months to follow the development of several methods and tools that show promise of affording practical means of developing such passed-up wealth.

The three specific developments referred to are (1) the apparatus and technique for logging geologic formations by use of the gamma ray, (2) the development of a tool that will drill laterally at any desired point in a well, cutting through steel casing and into even the hardest formation in one operation, retaining a sample of the formation in the hollow cutter head of the tool that is retractible and can be hoisted to the earth's surface with the geologic sample intact, and (3) the perfection of a method for milling or cutting-out and completely removing steel casing over any desired length. It is believed that only a relatively few men in the industry have conceived of the possibilities that might result if all three methods were combined in a technique for systematically testing and exploiting the older fields of the nation.

The first of these, gamma ray logging, has attracted much interest recently and has been described in interesting fashion in the literature.[1] The instrument used in gamma-ray logging is designed to measure the relative intensities of gamma rays emanating from the radioactive elements occurring naturally in geologic formations exposed in the walls of an oil well. Logs made by plotting these measurements have displayed remarkably close correlation with commercial electrical logs.[2] Possessing strong penetrating power, gamma rays have proved as reliable in cased as in open wells. In general, the sands encountered show up as radioactive "lows" and the shales as radioactive "highs."

The lateral-cutting tool referred to has not been made generally available yet but it has been perfected and is now being tested thoroughly on the Gulf Coast. Later, the results of these field tests and a full description of the tool's operation should prove interesting to the industry.

The third method listed, the milling of steel casing, is not new in the strict sense but its intensive use during recent months by one of the leading operators in the Illinois Basin has focused attention upon the value of this technique as a means of obtaining production from multiple zones in wells that have previously been cased with all-steel casing.

One of the predominating characteristics of the production in nearly all of the more important fields in the Illinois Basin is the number of oil-bearing formations that are found commercially productive in a single well. Consequently, although Illinois production, being predominantly from limestone and flashy, cannot be termed prolific in the usual sense of the term, operators in the area are favored by more than one "ace in the hole."

Milling Steel Casing in Loudon Field

Probably more intensive thought and study have been devoted to the problem of multiple-zone production in the Loudon field of Illinois than anywhere else in the area.

The practice in this field for the last two years has been to insert alloy sections in the casing string opposite upper producing strata and later drill-out these sections or remove them with acid.

During the field's earlier development, before these special alloys were adopted as standard practice, all-steel casing strings were installed in approximately the first 200 wells drilled, thus casing-off the upper formations. It was known, of course, that two (now three) commercial sands exist in this field but inasmuch as the cost of two wells at each location would be prohibitive, it was believed that gun-perforating the steel casing opposite the upper sands would provide ample opening into the hole. Attempts to establish satisfactory production rates in this manner were not entirely successful, however, because of the extremely "tight" nature of the sandstones in these formations. In short, a shot of nitroglycerin, usually a 40-qt.

[1] "Detection of Radioactive Cement in Cased Wells," by Lynn G. Howell and Alex Frosch, T.P. No. 1113, appearing in A.I.M.E. *Petroleum Technology*, November, 1939.
[2] Lynn G. Howell and Alex Frosch: *Geophysics* (1939) *4* (2), 106.

charge,[3] is essential in order to obtain a profitable rate of production.

Faced with the problem of gaining access to the upper formations in the 200 wells in which steel casing had been run, the operators finally decided to try the comparatively new method of completely milling-out the steel casing where desired. Initial tests employing this new cutting device were satisfactory and a program was mapped by which all the steel-cased wells in the Loudon field will eventually be milled-out. This milling program is now in progress, about one-third of the wells having been completed.

Details of Milling Operation

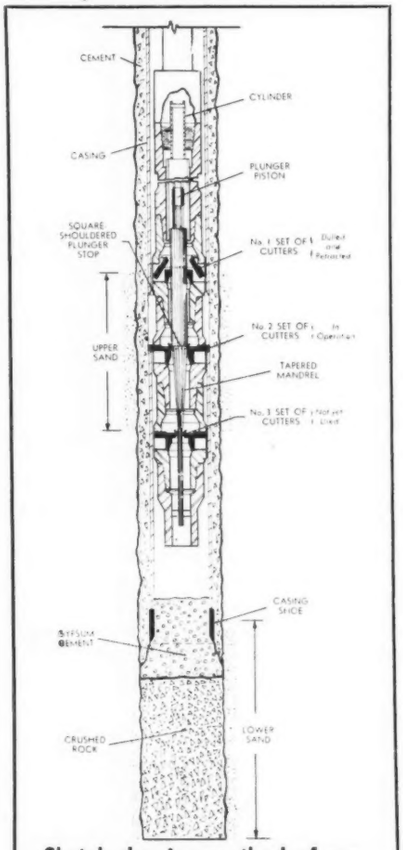
Operation of the milling device requires the use of rotary drill-pipe to suspend the tool, supply the rotation required for cutting, and circulate mud to actuate the tool and remove steel cuttings from the hole.

Five rotary rigs have been assigned to the milling program in the Loudon field in order to speed completion of this work. One of the rigs is a company-owned outfit, employing one of the new derricks that may be raised or lowered in one piece, and a unitized drilling machine. Four of the rigs are contract tools, three of which are of the portable-mast core-drill type. Small-diameter drill pipe, either 2⅞ in. or 3½-in., is used, this size being ample for the stresses encountered.

Two types of cutting mills are available for use—a cutting-through mill for starting a window in the casing, and an expanding casing mill comprising three sets of cutter blades. The principal difference between the two mills is that the first tool has cutter blades better designed to begin a cut into the casing. The second mill, having three sets of blades that succeed one another in action without coming out of the hole is used when the window to be cut involves more milling action than a single set of blades will withstand before becoming dulled.

After the drilling equipment is in place and ready for operation, the cutting-through mill is lowered into the casing to the point at which the upper edge of the window is desired, and rotation begins. The piston contained in the hollow center of the tool is forced downward by mud pressure supplied by the pumps until the piston mandrel strikes the cutter knives. Increased pump pressure causes the mandrel to expand the knives outward and upward against the inner casing wall. As the mill rotates, the knives cut through the casing until they become fully extended and are then held in cutting position by mud pressure and by the bottom edge of the cut they have made and on which further cutting is to be done.

Unrestricted mud circulation cannot be established in the hole until the knives are fully expanded. Thus full pump pressure is available during the initial cutting-through process so that a maximum force is exerted against the knives. The mud is retained within the tool until ports are uncovered by the piston as it drops when the casing wall is penetrated.



Sketch showing method of protecting lower sand during milling operation

With circulation established, the drill pipe and milling tool are lowered slowly and steadily as the cutting progresses and the window is lengthened. Steel cuttings are carried to the surface by the mud, which is maintained at from 40 to 45 Marsh seconds viscosity for best results. When the knives of the cutting-through tool become dulled, the tool is pulled from the hole, the knives collapsing and retracting as they enter the casing.

The average service life of each set of three blades ranges from 15 to 20 ft. of 6-in. casing. The approximate milling rate found to be most satisfactory is 1 ft. per hr. The weight carried on the tool is about 1500 lb. on a three-bladed mill.

When the total length of window to be cut does not greatly exceed the life of the cutting-through blades, the job may be completed without resorting to use of the multiple-tool. In fact, the majority of the wells in the Loudon field have been completed by the cutting-through tool alone.

The Expanding Casing Mill

The essential parts of the expanding casing mill are: the body assembly, the plunger cylinder, the plunger piston with sealing rings, attached to a long tapered mandrel, and three cutter heads, in each of which may be inserted 3 to 7 cutter knives made of SAE 4140 steel with special hard-facing alloy on the cutting edges.

The casing mill is lowered into the hole until it is opposite the open section of the casing. Mud under pressure is then pumped through the drill pipe to force the piston downward, breaking the strands of soft line with which the blades are tied.

The sliding inclined plane surface of the tapered mandrel forces the top (No. 1) set of knives outward into a horizontal position, ready to begin cutting on the lower edge of the casing window. The mandrel is held up by a square shoulder until the first set of blades is dulled; the mill is then raised until the blades strike against the top edge of the milled-out section, causing them to retract into the tool and permitting the mandrel to drop, actuating the second set of cutters. The same operations will bring the third and last set of cutters into action when the second set becomes dulled.

Protecting the Lower Formation

Before any milling work is done, the formation is filled with gravel and sealed with quick-setting cement. This protects the lower oil sand from contamination during the work. When the window has been completed and the upper formation has been shot, the well is cleaned out.

Cement Essential on Both Sides of Window

In the Loudon field, all oil strings are cemented from top to bottom to guard against the corrosive, brackish waters of the shallow sands in this area. Consequently, the edges of the casing windows are usually well-cemented and no further work is needed to seal-off the space behind the casing. In only a couple of wells has it been found that the cement was not adequate to support the lower casing section and it was necessary to re-cement.

In wells in which cement is only placed around the casing seat, the milling operation should be preceded by a cementing job, probably by gun-perforating above and below the proposed window and squeeze-cementing through the perforations.

[3] "Gas Injection at Loudon, Illinois," by R. J. Sullivan, T.P. No. 1173, A.I.M.E. *Petroleum Technology*, February, 1940.

Pressure Distribution About a Slotted Liner in a Producing Oil Well[1]

Tests on laboratory models simulating bottom-hole conditions reveal important information pertaining to effect of slot dimensions on production efficiency

Part 1

By FRANK G. MILLER[2]

Abstract

LITTLE INFORMATION concerning the nature of the flow of petroleum reservoir fluids in oil-bearing sands in the immediate vicinity of slotted or other types of perforated liners has been published even though information on this subject is of fundamental importance in many studies relating to oil-well behavior. The dearth of this scientific knowledge is acknowledged by many engineers and scientists, but the advantages to be gained by operators of oil-producing properties through proper selections and applications of perforated liners are just beginning to be recognized, generally, by them. The effect of slot size on the pressure distribution about slotted liners in producing oil wells was investigated in the laboratory under certain idealized conditions in a study having the purpose of obtaining further information for the guidance of engineers and operators selecting perforated liners.

A perforated liner, if functioning properly, prevents entry of sand into the well bore and at the same time permits the influx of oil, but flow restrictions caused by the liner materially affect the pressure gradient in the vicinity of the wall of the well. The magnitudes of the energy losses incident to the flow of reservoir fluids through oil-bearing sands to the insides of liners depend partly on the size of the slots in the liners as well as on the characteristics of the oil sand. By improved liner design and proper selection of liners it may be possible to reduce these losses and thereby extend the natural flowing lives of wells and increase the initial flow capacities of small wells; these are factors of economic importance to operators because of lower costs of producing naturally flowing wells as compared with operating costs resulting from the use of artificial lifting methods.

[1]Part of a more detailed thesis submitted to the University of California in partial fulfillment of the requirements for the degree of master of science in mechanical engineering. This paper also appeared as T.P. No. 1222 in A.I.M.E. *Petroleum Technology*, August, 1940.

[2]Assistant petroleum engineer, U. S. Bureau of Mines, Petroleum and Natural Gas Division, San Francisco, California.

FRANK G. MILLER

graduated from the University of California in 1933 with B.S. degree from College of Mining, majoring in petroleum engineering—After three years with the Union Oil Company of California as chemist in the refining laboratory at Oleum, California, and as a roustabout in the Los Angeles Basin Miller became associated with the San Francisco office and laboratory of the Petroleum and Natural Gas Division of the U. S. Bureau of Mines—Since then he has been engaged in petroleum production research for the Bureau, specializing in problems concerning the flow of oil, gas, and water through reservoir sands—He was coauthor with H. C. Miller of paper entitled "Resumé of Problems Relating to Edgewater Encroachment in Oil Sands" presented at the A.A.P.G. meeting in New Orleans in March, 1938, and published as Bureau of Mines Report of Investigations No. 3392—Received degree of M.S. in mechanical engineering, with special study in fluid mechanics, from the University of California in 1939—Is a junior member of the America Institute of Mining and Metallurgical Engineers and an associate member of Sigma Xi.

The laboratory investigation, described in the report, was conducted with a fluid flow-through-sand apparatus and an electrolytic conduction model, both of which simulated the objective. Only rectangular slots, having their long axes parallel to the well axis, were considered in this study. The more pertinent results of the investigation suggest these conclusions:

(1) The formation of a sand bridge over a rectangular slot does not entail an additional energy loss provided the slot is wide enough, regardless of the rate of flow.

(2) Neglecting the effect of sand bridging over slots, the crowding of the flow lines in the sand near a slot causes a separate loss that is dependent on both slot width and length, but length is the more important variable.

(3) A slotted liner does not affect normal flow conditions in the sand beyond a distance, measured from the well axis, of 3 times the well radius.

The laboratory method used would be applicable in studying possible pressure conditions about most types of perforated casings used in producing oil wells.

Introduction

The lower cost of producing oil from naturally flowing wells compared to production costs accruing from artificial lifting methods has stimulated much research, with the joint purpose of extending the natural-flowing life of wells and of increasing the productivity of small wells. The laboratory investigation described herein was made to determine the effect of a slotted liner on the pressure gradient in the vicinity of the wall of a flowing well. In recent years engineers have recognized, to an increasing extent, the importance of correct slot sizes in liners as a means of improving well performance. The use of a slotted liner in an oil well affords a method of preventing the entry of sand into the well bore and at the same time permits the influx of oil. Flow restrictions caused by the liner induce energy losses between the oil-bearing formation and the inside of the liner that may be reduced by improved liner design and thereby increase the flow capacity of wells. These losses have been evaluated for different-size rectangular slots, and means are suggested for reducing them.

The dearth of information concerning the nature of the flow of fluids from unconsolidated sands through small openings in the walls of pipes—as represented by the flow of oil from

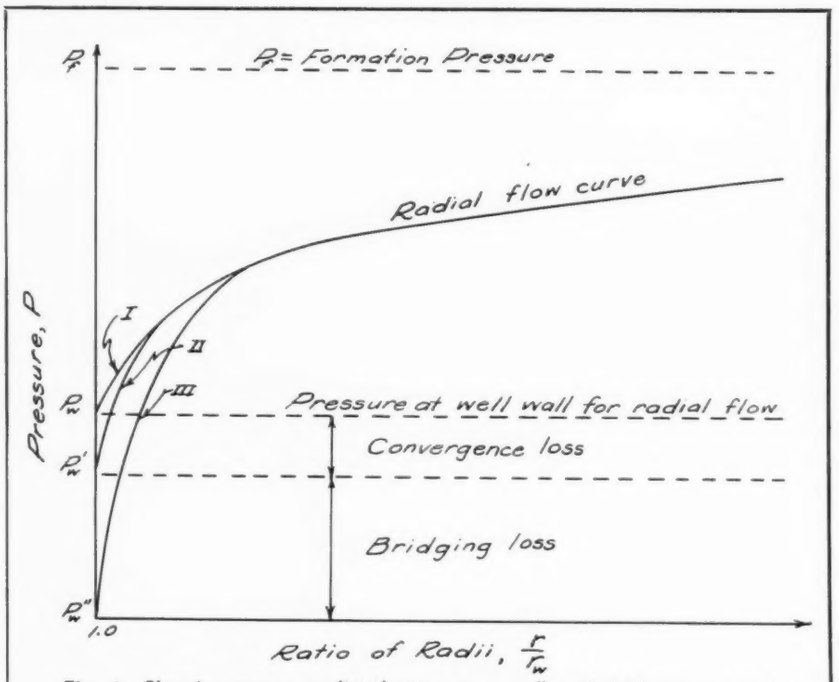


Fig. 1. Showing pressure distribution near well wall. (All curves apply to a single flow rate)

an oil sand into a slotted liner—is acknowledged. Although the benefits to be realized by operators through the use of optimum liners is just beginning to be recognized generally, Coberly[3] in 1937 pointed out that the functioning of screen casing is an important factor in the production of oil, as it materially affects the pressure gradient in the immediate vicinity of the well and controls the production of sand with the oil. He states further that although there has been some research and considerable speculation relative to the shape, size, position, and arrangement of openings in screen and perforated casing, few published data on which to base their selection have been available.

From his study on the selection of size of oil strings for wells in California, Parks[4] concluded, in part, that the perforated section of the oil string deserves continued study, especially with respect to the selection of perforations.

Research engineers are striving constantly to reduce energy losses occurring near well bores, and some of their findings have resulted in the growing use of gravel-packing methods, which lends even more significance to the problem of selecting optimum liners, as application of these methods usually requires slotted or other types of perforated liners.

[3] "Selection of Screen Openings for Unconsolidated Sands," by C. J. Coberly, A.P.I., *Drilling and Production Practice*, 1937, p. 189.

[4] "Selection of Size of Oil Strings for Wells in California," by E. K. Parks, A.P.I., *Drilling and Production Practice*, 1937, p. 47.

The present study was made to obtain further information for the guidance of engineers and operators in selecting slotted liners and to develop a laboratory method that may be used in analyzing possible pressure conditions surrounding most types of perforated casings used in producing oil wells, so that the present deficient fund of knowledge on this important subject may be expanded. It may be concluded from this investigation that the formation of a sand bridge over a rectangular slot does not entail an additional energy loss, provided the slot is wide enough, regardless of the rate of flow. In fact, bridging of the sand may indirectly cause the equivalent of an energy gain; however, even a small decrease in width of slot below a certain critical value (depending on the grain size distribution of the sand) will cause a considerable additional loss of energy, assuming a constant rate of flow and slots of the same length. Crowding of the flow lines in the sand near a slot causes a separate loss (termed herein a convergence loss), which depends on both slot width and length. The convergence loss decreases as the slot width or length is increased, assuming a constant rate of flow, but length is the more important variable in this instance. A slotted liner does not affect normal flow conditions in the sand beyond a distance, measured from the well axis, of 3 times the well radius.

Discussion of Problem

At the beginning of this investigation the following assumptions were made concerning the bottom-hole conditions of a producing oil well and the oil-sand reservoir it penetrates: (1) Conditions of steady-state flow exist, (2) a single-phase homogeneous liquid is being produced, (3) no contaminating material, such as drilling fluid, is present between the liner and the face of the oil-bearing sand, (4) the well is vertical and completely penetrates a horizontal sand stratum of uniform thickness occurring between two impermeable strata, and (5) the flow is wholly viscous.

If the foregoing assumptions are made, with the added requirements that the sand be immobile and of constant permeability and that no liner be present, the pressure in the sand can be shown to vary with the logarithm of the radial distance from the well axis, in accordance with the radial flow equation:[5]

$$P = \frac{Q\mu}{2\pi kh} \log \frac{r}{r_w} + P_w \quad \ldots \quad (1)$$

where P is the pressure at a radial distance, r, from the well axis; Q is the volumetric rate of production, μ is the fluid viscosity, h is the sand thickness, k is the sand permeability, and P_w is the pressure at the sand face at r_w, the well radius.

The pressure distribution suggested by equation (1) would not exist in the vicinity of the well wall if the sand were unconsolidated or a liner were present. For convenience in discussing the pressure distribution in the sand next to a liner, reference is made to Fig. 1, showing a schematic diagram of pressure conditions in the sand for a single flow rate. The pressure distribution for purely radial flow is shown by curve I, in which the pressure difference between some point in the formation remote from the well and some point at the sand face is $(P_f - P_w)$, P_f being the formation pressure and P_w the pressure at the well wall.

If a slotted liner is present the streamlines must converge more than they do for radial flow so that the fluid will pass into the slots. This crowding together of the flow lines in the sand near the slots causes an additional loss in pressure head equal to $(P_w - P_w')$ in the diagram. Curve II indicates the pressure distribution in the sand when only the additional streamline convergence is considered and shows that the flow would be radial beyond this region of slot influence but that the pressure gradient near the well wall would be steeper because of it. Further, the abscissa of the point at which curve II begins to deviate from curve I affords a measure of the outer limit of the region of slot influence.

[5] *The Flow of Homogeneous Fluids Through Porous Media*, by M. Muskat. First edition, McGraw-Hill Book Company, Inc., New York, 1937, p. 153.

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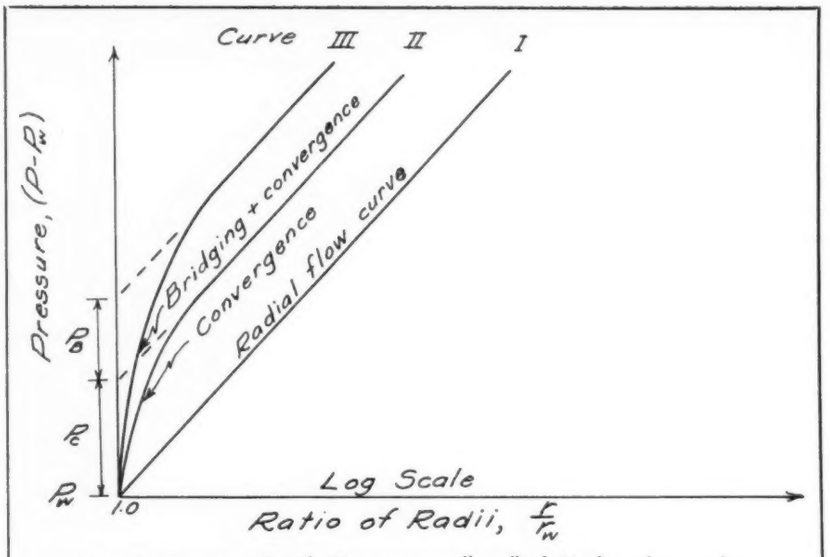


Fig. 2. Pressure distribution near well wall plotted on log scale. (All curves apply to a single flow rate)

Actually, an unconsolidated oil sand is held back by a liner, as the sand forms a bridge over each slot even though some of the grains may have equivalent spherical diameters less than the slot widths. On a theoretical basis it may be predicted that the sand bridge would be in the form of an arch and that the smaller grains at the arch would be wedged tightly between the larger grains. It follows that the sand bridge probably would have a lower permeability than the main sand body so that an additional head loss would result. In contrast, it may be contended with equal logic that a sand bridge could form by tight wedging of larger grains and a removal of fine grains through a slot before a bridge was formed. Under this condition the resulting permeability of the sand just outside a slot would be greater than that of the main sand body, so that the effective head loss due to bridging could be zero or negative. Curve III in the diagram, illustrating the condition in which wedging of the smaller grains between the larger grains decreases the permeability of the sand at the bridge, includes both the head loss due to convergence ($P_w - P_w'$) and a positive head loss due to bridging ($P_w' - P_w''$) so that the pressure difference between some point in the formation remote from the wall and some point at the outside wall of the liner would be ($P_f - P_w''$). It will be apparent that curve III deviates from the radial flow curve at a distance limiting the region of slot influence and that within this region the pressure gradient is steep because of the combined effect of streamline convergence and bridging.

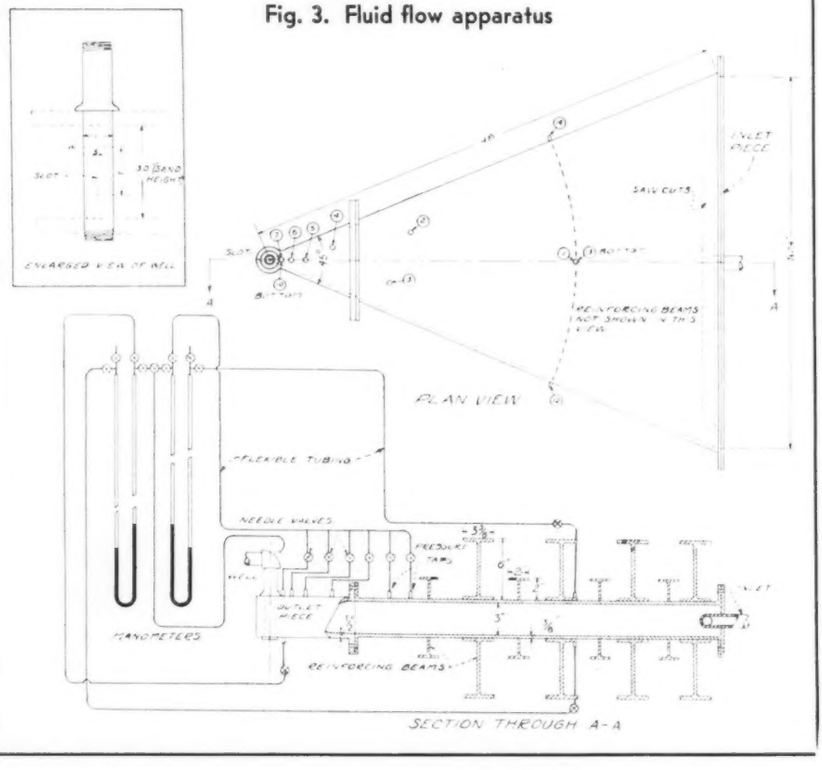
In field practice the formation pressure (P_f) is taken as the static bottom-hole pressure, determined after a well has been shut-in long enough to permit equilibrium conditions to become established in the sand. The bottom-hole pressure can be determined while a well is producing at a constant rate. This pressure is P_w'', in the diagram, if the head loss due to the "orifice action" of the slots is neglected. Head loss due to orifice action is the pressure drop that occurs across the slots even if no sand is present (similar to the pressure differential across an orifice in the flow of fluids in pipe lines), but as this loss was found to be relatively small in the experiments it is neglected in this analysis.

As an aid in the discussion of experimental methods for use in determining convergence and bridging losses, the pressure distribution curves of Fig. 1 are plotted on semilogarithmic paper with the pressure at the well wall taken as the datum. (See Fig. 2.)

Equation (1) indicates that the pressure curve for purely radial flow is a straight line on semilogarithmic paper and that this line terminates at the point $\left(\frac{r}{r_w} = 1, P = P_w\right)$ if the well-wall pressure is taken as the datum. Curve I, Fig. 2, illustrates the pressure gradient in the sand under conditions of radial flow. If a slotted liner is present and if the hypothesis is proposed that the sand is homogeneous to the outside wall of the liner, the pressure distribution beyond the region of convergence would be represented by a straight line parallel to the radial flow curve on semilogarithmic paper, but within this region the pressure gradient would be steeper, as shown by curve II. Similarly, curve III represents the conditions when both convergence and bridging are manifest.

If curves II and III are extrapolated to the pressure axis, their equations,

Fig. 3. Fluid flow apparatus



considering one constant flow rate, would have the form:

$$P - P_w = m \log\left(\frac{r}{r_w}\right) + b \quad . \quad (2)$$

where m is the slope and b is the intercept on the pressure axis. Slope m, for either curve, depends on the volumetric rate of flow, the sand thickness, the fluid viscosity, and the permeability of the sand beyond the region of slot influence. If only streamline convergence is considered, b would depend on the slot pattern and on the slot dimensions, and the value of b would represent the additional pressure loss (P_C) due to convergence. In an actual case, b would depend also on the added flow resistance due to the sand bridge (assuming a positive head loss due to bridging), so that $b = P_C + P_B$ in Fig. 2.

In evaluating the experimental energy losses, data were obtained with laboratory apparatus designed for use in determining values of b (see equation 2) or total losses corresponding to different-size rectangular slots. The part of the total loss due to convergence was computed from the results in each instance. Measurements of the outer limits of the region of slot influence were made. Head loss caused by the slots alone (no sand present) was shown to be relatively small.

Two different sets of laboratory apparatus were used: (1) a fluid flow-through-sand apparatus (the prototype) and (2) an electrolytic conduction model made similar to the prototype. Each apparatus simulated the objective and was built so that the potential distribution across a radial sector adjoining the well could be measured.

Through the physical analogy of hydraulic and electric currents the voltage potentials incident to the flow of electric current through the electrolyte in the electrolytic conduction model correspond to the pressure differentials incident to the flow of fluid through the porous medium in the prototype. The conducting medium of the model, however, could be made uniform to the well wall, whereas the sand in the prototype could not, principally because of bridging over the slots. Thus the electrical model could be used to determine convergence losses alone, and the fluid flow apparatus could be used to determine losses resulting from convergence plus bridging and losses caused by the slots alone (orifice action). Hence, experiments could be performed on both sets of apparatus and the results properly combined to show the respective losses from convergence and bridging for certain different-size rectangular slots.

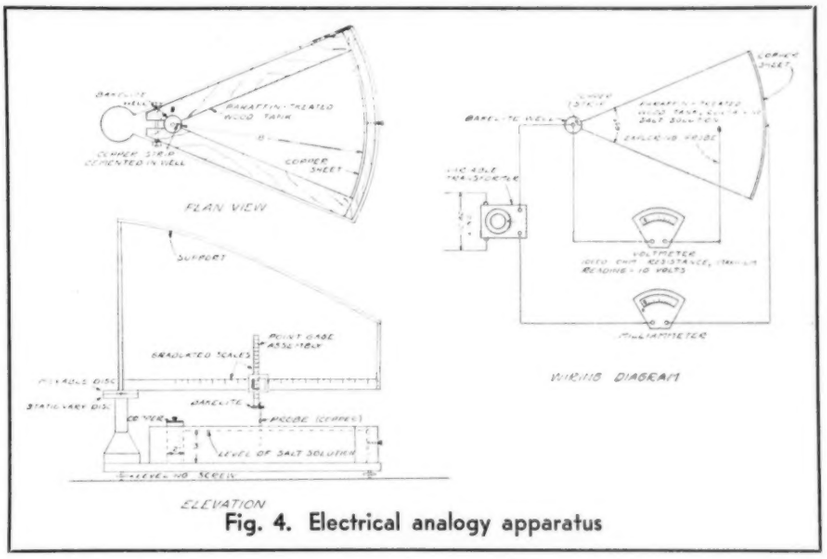


Fig. 4. Electrical analogy apparatus

Apparatus

Description of fluid flow through sand apparatus. The fluid-flow apparatus, illustrated by Fig. 3, was designed to simulate the flow conditions about a single slot in an actual liner. The apparatus was built so that a volume of sand of uniform thickness (3 in.) under an area in the form of a 45-deg. sector would be drained through a single test slot in each experiment, which simulates the flow conditions about one slot in an actual liner having 8 rows equally spaced about its circumference. For ease of construction, the apparatus was designed as a wedge-shaped pressure vessel (see plan view, Fig. 3). Thus the sand with which the vessel was packed had the form of a triangular block 3 in. thick with two equal 48-in. sides that would intersect at the experimental well axis if projected. The angle between the equal sides of the sand block was 45 deg. The triangular shape of the vessel (in contrast with the theoretical sector of a circle) did not prevent the flow in the sand from being radial some distance from the experimental well, as shown later in the section "Experiments in Flow of Fluid Through Sand."

The pressure vessel was designed so that the maximum total deflection between the upper and lower plates would not exceed 1 percent of the sand thickness when the vessel was under a pressure equal to one and one-half times the maximum working pressure. The desired deflection requirements were satisfied by constructing the tank with a composite of cast- and welded-metal parts.

The flanged outlet piece was cast iron ½ in. thick and the built-up part of the vessel was made from ⅜-in. boiler plate to which standard 6-in. I-beams and 2-in. T-beams were welded as reinforcing members. The inlet piece accommodated a 1-in. pipe fabricated in the form of a "T" and having numerous vertical saw cuts, as shown in the sketch, to insure adequate distribution of the incoming liquid across the sand.

The experimental "well", made of brass, has a 1-in. outside diameter and a 1/16-in. wall thickness, and was machined to fit the outlet casting snugly. As only a 45-deg. section of the lateral surface of the well could be opposite the sand in any one test several slots of preassigned lengths and widths were cut in the same well and used independently.

The pressure taps, placed as shown in the sketch, are short, ⅛-in. standard pipe nipples having fine brass screens soldered to the ends that screwed into the tank, but they do not extend beyond the inner surface of the tank.

In the sketch only one manometer assembly is shown, but it was possible to change the assembly so that these instruments could be used to best advantage in each experiment.

Description of electrolytic conduction model. In constructing the electrical analogy apparatus (Fig. 4) a wooden tank, open at the top and containing a weak solution of sodium chloride through which an electric current could be passed, was made similar to the sand-filled pressure vessel of the fluid-flow experiments, in that the depth of the electrolyte was 3 in. in the container, which had the shape of a 45-deg. sector. The wood of the tank was treated with hot paraffin to render it non-conducting to the current. The well was made from a solid circular bakelite rod 2 in. in diameter, into which vertical grooves were cut to accommodate copper strips that were analogous to slots in the

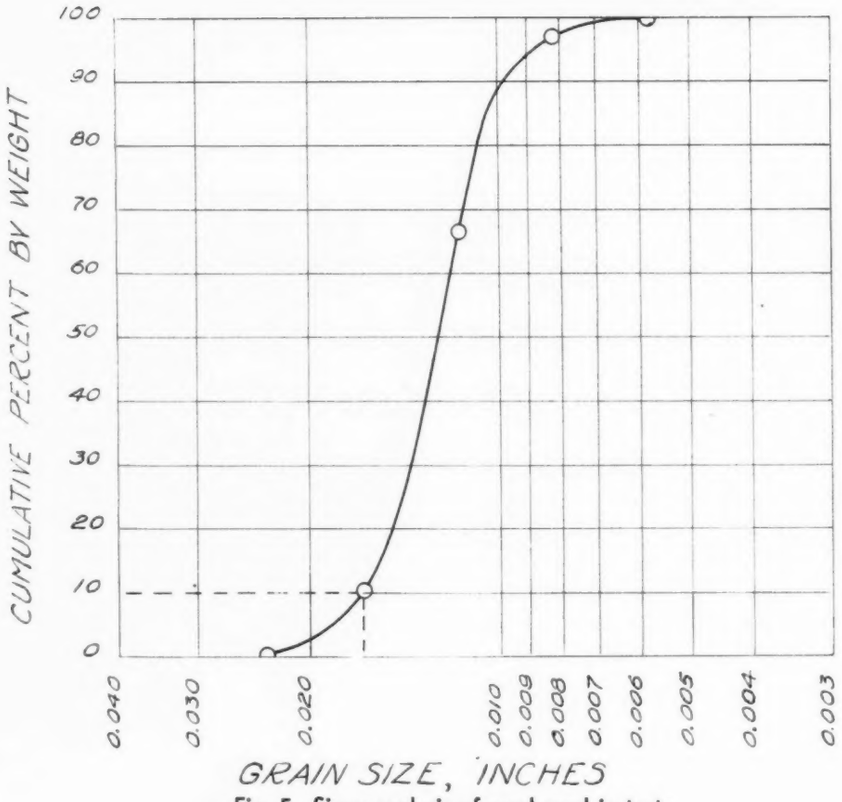


Fig. 5. Sieve analysis of sand used in tests

prototype. Six different strips were cemented in grooves in the same bakelite cylinder, but each could be used independently. A copper sheet 1/16 in. thick was set vertically at the inside wall of the tank opposite the well so that it laid along an arc of a circle (or cylinder) centered at the well axis. An electric current could be passed through the electrolyte in the tank between the copper sheet acting as one electrode and a copper strip in the well acting as the other.

An exploring probe was used to determine the voltage distribution in the tank away from the "well" during the current flow, but was not employed to obtain potential and flow lines in the immediate vicinity of the copper strips. The probe was a copper rod about 1/10 in. in diameter mounted on a point gauge assembly, but insulated from it with bakelite, as shown in the sketch. The immersion depth of the probe was determined with the point gauge assembly. The horizontal distance between the probe and the well wall was determined from measurements taken on a scale above and parallel to the surface of the electrolyte. The horizontal scale was bolted to a movable circular metal disk setting above a similar stationary disk. Both disks were mounted on a standard supporting the whole probing device, as shown in the sketch. The angle between the horizontal scale and a center line passing through the well axis and along the surface of the electrolyte was computed from the relative position of the two disks.

The source of power used was the 110-v., 60-cycle local city supply. Alternating current was used to minimize polarization at the electrodes.

The wiring diagram of Fig. 4 shows schematically how the apparatus was assembled for use. A variable transformer was used to reduce the voltage and to eliminate the effect of small fluctuations in the power supply from the city line. The potential drop between the probe and the well wall was indicated on a voltmeter of high resistance so that only a negligible current could pass through the probe. A milliammeter connected in series with the tank indicated the total current flow.

Experiments and Results

Experiments on flow of fluid through sand. The flow restrictions due to a slotted liner in an oil well result in a steep pressure gradient near the well wall. The total loss of head caused by these restrictions are, in this analysis, divided into three parts: (1) Loss due to slots alone—present even in the absence of sand; (2) convergence loss due to a closer grouping of the streamlines in the sand near a slot, and (3) loss due to a possible reduced permeability of sand bridging the slots.

In the field, two-dimensional flow would be realized if the liner of a well, completely penetrating a horizontal and productive sand of constant thickness, had vertical slots equal in length to the thickness of the sand. In this special case the paths traced by the fluid particles as they move toward the well would be the same in all horizontal planes parallel to the sand stratum. The flow in the immediate vicinity of the well would be three-dimensional for slots that are shorter than the sand thickness, as the streamlines necessarily would converge in both vertical and horizontal planes in the vicinity of the slot.

In the fluid flow experiments five slots, analogous to the copper strips used in the electrolytic conduction model study, were tested. Three of these slots were for two-dimensional flow; that is, each of these had a length equal to the thickness of the sand (3 in. in all experiments) so that the distribution of flow lines would be identical throughout the sand in all planes perpendicular to the well axis. The width of these slots, designated as A, B, and C, was 0.010, 0.020, and 0.032 in., respectively. As the diameter of the experimental well was 1 in. the ratios of the width of slots A, B, and C to the diameter of the well were 0.010, 0.020, and 0.032, respectively. Slots G and F were 0.010 and 0.020 in. wide, respectively, but were for three-dimensional flow as each was only 1½ in. in length. In each test, the slot was placed with its center midway between the flat upper and lower plates of the pressure vessel confining the sand so that there was ¾ in. of blank pipe at each end of the slot opposite the sand. Hence three-dimensional flow resulted as the flow lines in the vicinity of the slot had to converge in vertical and horizontal planes to pass into the slot.

The losses due to the five slots alone were measured independently in the fluid flow apparatus as well as total head losses resulting from all influencing factors. The convergence losses corresponding to these slots were measured independently in the electrical analogy apparatus. By combining results, therefore, from both sets of experiments—electrical and fluid flow—pressure losses contributing to the total loss of head for the designated slot could be evaluated.

The same sand was used in all experiments, but the pressure vessel was cleaned and repacked with sand before each slot was tested. The sand was a cleaned white beach sand from Monterey, California, composed essentially of quartz and feldspar grains. Fig. 5 is the sieve analysis curve of the test sand.

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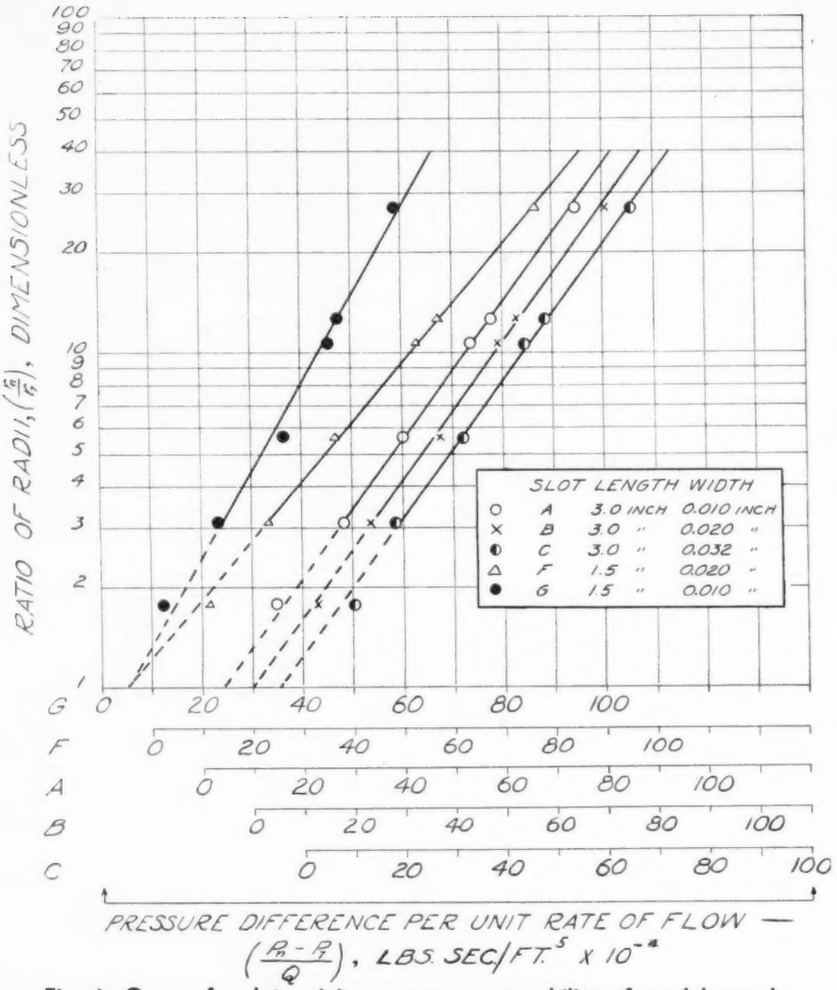
RATIO OF RADII, $(\frac{r_n}{r_7})$, DIMENSIONLESS
SLOT LENGTH WIDTH
A 3.0 INCH 0.010 INCH
B 3.0 " 0.020 "
C 3.0 " 0.032 "
F 1.5 " 0.020 "
G 1.5 " 0.010 "
G
F
A
B
C
0 20 40 60 80 100
PRESSURE DIFFERENCE PER UNIT RATE OF FLOW — $(\frac{P_n - P_7}{Q})$, LBS. SEC/FT.^{5} X 10^{-4}

Fig. 6. Curves for determining average permeability of sand beyond region of slot influence

particular fluid used in experiments of this kind is of no importance, as the results are relative. Furthermore, the losses corresponding to the flow of any other liquid could be computed if its viscosity relative to water were known, provided Darcy's law described the flow.

In discussing the test procedure, reference again is made to the sketch of the apparatus shown in Fig. 3. The inlet end of the pressure vessel was made flat for ease of construction, but it was predicted that the flow would become radial a short distance from the inlet. To verify this prediction pressure differences corresponding to the highest flow rates were measured between taps 1, 12, 13, and 14 (all on an arc of a circle centered at the well axis) each time the apparatus was packed with sand. As the measured differences were found to be negligibly small in all tests the flow was known to be radial between this circle and some inner circle limiting the region of slot influence.

The pressure distribution between taps 7 and 1 corresponding to five flow rates, was determined for each slot that was placed opposite the sand, and the data obtained were used to evaluate the average permeability of the sand in the apparatus beyond the region of slot influence. Fig. 6 is a graphic representation of the permeability data, in which $P_n - P_7$ is the pressure difference in lb. per sq. ft. between some tap at a radial distance, r_n, from the well axis and tap 7 (at r_7). Q is the rate of flow, in cu. ft. per sec. The legend on the graph denotes the slot that was opposite the sand when each set of data was collected. The curve drawn for each set is the best straight line through the five greatest values of $\left(\frac{r_n}{r_7}\right)$. The average permeability may be computed from equation (1), rearranged for a 45-deg. sector:

$$\log \frac{r_n}{r_7} = \frac{\pi\, hk}{(2.303)\ (4)\ \mu}\left(\frac{P_n - P_7}{Q}\right) = c\left(\frac{P_n - P_7}{Q}\right) \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where h is the sand thickness (ft.), k the sand permeability (sq. ft.), μ the water viscosity (lb-sec. per sq. ft.), and c the slope taken from Fig. 6. It follows that:

$$k = \frac{(2.303)\ (4)\ \mu\, c}{\pi\, h} \quad . \quad . \quad . \quad (4)$$

For the purpose of this analysis a consistent ft-lb-sec. system of units has been used, and therefore the permeability was computed in sq. ft., but as this, perhaps, is an unfamiliar unit for permeability, the corresponding values in darcys are given also (darcys $\times$ 1.062 $\times$ 10^{-11} = permeability in sq. ft.) in Table 1.

TABLE 1

Average permeability of sand away from well during tests of slots

Slot facing sand	Permeability	
	ft.^{2} $\times 10^{11}$	Darcys
A	57.9	54.6
B	58.9	55.4
C	59.9	56.4
F	53.1	50.0
G	69.7	65.6

EDITOR'S NOTE: This article will be continued in an early issue.

Helium Production at Amarillo, Texas, Passes 100,000,000 Cu. Ft.

Production of helium from natural gas at the world's only operating plant —operated by the U. S. Bureau of Mines at Amarillo, Texas—recently reached an 11-year total of 100,000,000 cu. ft., the Bureau reports. Production from other government plants, not now operating, bring the all-time total nearly to 150,000,000 cu. ft.

For 27 years known to exist as an element on the sun, finally helium was found on the earth, but only as a chemical curiosity with a rarity value equivalent to $2500 a cu. ft. Now it is being produced for a variety of uses at a cost of less than 1½ cents per cu. ft. Besides its unique property as a buoyant non-explosive gas for air ships, helium makes both deep-sea divers and asthma sufferers breathe more freely, and helps the weather man in his predictions.

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Testing Boiler Feedwater

Clear, concise tests contribute to operating efficiency of gasoline plant

By ROY W. MACHEN
Superintendent, Hamman Exploration Company

THE proper conditioning of water for use in boilers necessitates a definite amount of plant laboratory routine. These periodic checks are easily made by certain simple rapid methods of determination. These testing methods are not represented, however, as being sufficiently complete to replace the more exact procedures outlined in "The Standard Methods for the Examination of Water and Sewage," published by the American Public Health and American Water Works Association, New York City. They should be considered in fact as only routine methods by which boiler water and boiler feedwater may be examined so that intelligent boiler operation may be made a permanent part of plant operation rather than an erratic procedure resulting in inefficiency.

Reporting Results

Before an intelligent interpretation can be made of a water analysis, knowledge of the two methods of expressing the quantities of substances present is a prime requisite.

Substances found in water samples are usually of such small percentages that the actual methods of analysis as well as the methods of expressing the results of the analysis have been especially developed. A great many laboratories report the results of their analyses in parts per million (p.p.m.). If one wished to reduce one part per million to a percentage basis, he would find it equal to only one ten-thousandth of 1 percent. This method has been adopted as standard by the U. S. Government in the preparation of its reports. Many of the larger and more outstanding laboratories as well as numerous scientific societies have also adopted the p.p.m. method as standard.

Numerous laboratories, however, still use the grains per gallon method of expression. Many of these laboratories give quantities on their reports in both p.p.m. and gr. per gal.

The methods outlined for plant testing will give results in parts per million. Conversion of p.p.m. to gr. per gal. may be accomplished by dividing the results as expressed in p.p.m. by 17.1, or by multiplying the results as expressed in p.p.m. by 0.058.

ROY W. MACHEN

received a bachelor's degree from Oklahoma City University in 1927—Employed for six and one-half years by the Peppers Gasoline Company as refinery clerk, refinery and gasoline plant chemist, and gas engineer—Later saw service with several independent refining companies—Is now superintendent for Hamman Exploration Company.

The Ionic Form of Report

Many chemists prefer to report the metals and acid radicals present in the water individually and do not attempt to combine them on their report sheets in the forms in which they would probably deposit in the boiler. This method of individually reporting the elements or radicals in the water is called the Ionic Form of Report.

It has the disadvantage of not characterizing the water analyzed as to its suitability for boiler feed purposes. Before the engineer would be able to know what types of deposition he could expect in his boiler if he uses the particular water analyzed, he would have to acquaint himself with the equivalent combining weights of metals and acid radicals.

The ionic form combines simplicity and ease in quantitatively comparing mineral solids as reported with those reported in other tests.

Combined Form of Report

The method of reporting analyses that is probably preferred by most engineers is that which is known as the combined form. It more clearly pictures the types of solids that are likely to be deposited in a boiler should that particular water be used for boiler feed purposes. It has the distinct disadvantage of being undependable. By that we mean that because of the lack of agreement between chemists as to just the proper method and manner of combination, analyses on water samples from the same source sent to several laboratories would result in as many different reports of mineral combined solids.

As there is more than one method of making these combinations and there is no method of analysis by which one may determine exactly how the elements exist in the water itself, the ionic form of report has been quite generally admitted to be the better.

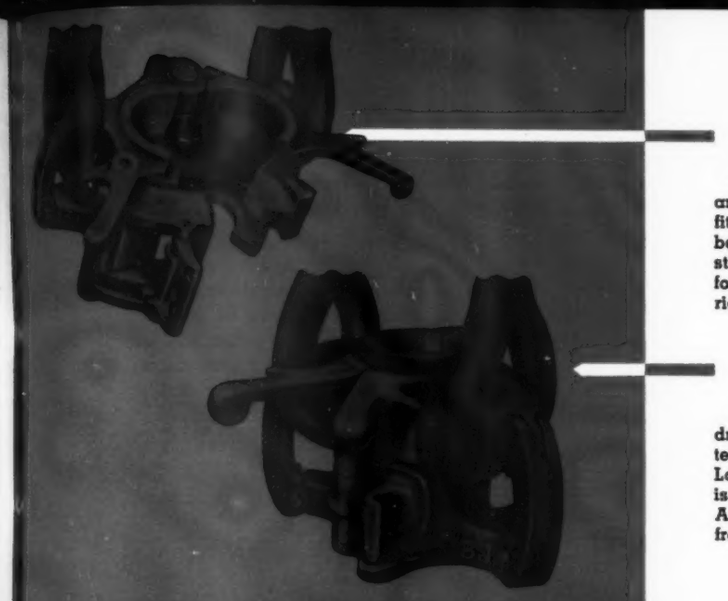
Ionic Form with Equivalents

A third method of reporting water analyses combines the ionic form, in which the elements are reported individually, with a supplementary schedule in which the metals and radicals are reduced, in much the same manner as common fractions, to a common denominator. In this schedule, the unit of expression is the equivalent part per million (e.p.m.). The results of the test as ionically reported can be reduced to equivalent p.p.m. by dividing the elements in p.p.m. by the equivalent weight of that substance.

The equivalent weight of any substance is its atomic weight divided by the valence of that substance.

The valence of an element is a number that represents the capacity of the atomic weight of that substance to combine with or displace the atomic weight of other elements. The unit of this capacity to combine with or displace is that of one atomic weight of hydrogen or chlorine.

In order to find the valence one may resort to the formula of one of the simple compounds of the substance that contains another substance of known valence. Hydrogen and chlorine are both univalent, that is, the valence of an atomic weight of hydrogen or chlorine is one. For instance if it is desired to know the equivalent weight of magnesium, knowing that chlorine is univalent and that the formula for



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magnesium chloride is $MgCl_2$, it is evident that one atomic weight of magnesium combines with two atomic weights of chlorine. The atomic weight of magnesium, 24.32, when divided by two will give, therefore, the equivalent weight, 12.16. If it is desired to know the equivalent weight of magnesium chloride, one molecule of $MgCl_2$ contains one atom of magnesium and two atoms of chloride. The weight of one molecule of magnesium chloride is equal to the atomic weight of one atom of magnesium plus the atomic weight of two atoms of chlorine: 24.32 plus 2 times 35.46, or 95.24. As the equivalent weight is equal to the atomic or molecular weight divided by the valence, and the valence of magnesium chloride is two, the equivalent weight of $MgCl_2$ is 95.24 ÷ 2 or 47.62.

This method of report has all the advantages of the ionic form and of the combined form of reports. It has found favor with the committees of several technical societies.

The total hardness in terms of calcium carbonate is easily determined from this form of report by adding the calcium and magnesium equivalent parts per million, e.p.m., and multiplying their sum by 50, the equivalent weight of calcium carbonate.

Control Testing Methods

The tests usually made in the plant laboratory on raw water are for: hardness, alkalinity, causticity, or acidity. In numerous cases a chloride test is made especially on waters coming from near the coast as a large portion of coastal well waters are brackish and contain large amounts of chlorides.

If the water to be used for boiler feed purposes is treated in an external system, the treated water will be tested for: hardness, alkalinity, causticity, chlorides, and sulphates.

The water sample taken from the boiler will be tested for: alkalinity, causticity, chlorides, and sulphates. It is entirely possible that the laboratory will in many cases test for total and dissolved solids.

One of the first results tabulated by a competent laboratory in making a raw water analysis is turbidity. This test is seldom made in the plant laboratory as it does not properly fall in the control testing classification. Turbidity of a water is due to the presence of finely divided particles of suspended matter that may consist of organic matter, silt, clay, and other materials. Turbidity is always expressed in terms of silica (SiO_2) and it must be understood that the turbidity result does not mean that there is silica present in the water as a direct contributing factor toward its turbidity.

Highly turbid waters should not be used untreated for boiler feed purposes as the finely divided particles that are in suspension will concentrate and settle-out in the boiler causing rapid scale formation in many cases and foaming in others.

The proper sampling of water for testing purposes is absolutely necessary if reliable results are to be obtained. Proper precautions to obtain an average and representative sample must be taken. The sampling of boiler feed waters and concentrated boiler waters must be done at a time when representative operating conditions prevail in the system. Hot feed and boiler waters must be cooled as they are taken and only after the sampling lines and connections have been well flushed out. If these waters are not cooled at the time of sampling, flashing into steam of a portion of the water drawn will occur, resulting in a reduction of the dissolved gases present and a concentration of the dissolved solids. Clean, well-flushed bottles made from a good grade of glass capped with cork stoppers are considered satisfactory for the taking of boiler samples.

Hardness

Hardness of water is expressed in terms of calcium carbonate ($CaCo_3$). Calcium and magnesium salts, and appreciable amounts of iron and aluminum are responsible for hardness.

As hardness in water is the characteristic power of water to consume soap, a standard soap solution is used to make this test. The soap solution will have a lather factor that will vary from 0.4 to 1.4 ml. This factor is the amount of standard soap solution necessary to produce a permanent lather in a 50 ml. sample of distilled water.

In making the test for hardness, 50 ml. of the sample at hand is measured into a bottle. The soap solution is added in small amounts from a burette and the sample shaken vigorously after each addition until a permanent lather will stand for five minutes without breaking when the bottle is laid on its side. There often is a point in the test when a lather will appear but which will break upon the addition of more soap. This false endpoint (ghost point) should be noted and recorded as it may be considered as the dividing line between the calcium and magnesium salts. The final burette reading after subtracting the lather factor and multiplying by 20 is the total hardness of the sample in parts per million and in terms of calcium carbonate.

If the hardness test takes more than 10 ml. of solution, an aliquot portion of the sample may be diluted to 50 ml. with carbon dioxide-free distilled water and the results multiplied by the appropriate factor.

If it is desired to express the test results directly in terms of grains per gallon, a sample of 58.3 ml. should be taken for the test instead of 50 ml. The results in grains per gallon can be read directly from the burette and in terms of calcium carbonate after the lather factor has been subtracted.

Hardness is expressed in three ways. Carbonate hardness is that due to the presence of calcium and magnesium carbonate and bicarbonate salts and is calculated from the hardness and alkalinity determinations. If the hardness is greater than the methyl orange alkalinity the carbonate hardness is equivalent to the total alkalinity and the excess hardness is termed non-carbonate hardness. When the total hardness is less than or equal to the methyl orange alkalinity there is no excess and all hardness of the water is carbonate hardness.

Alkalinity

Alkalinity in a natural water is due to carbonates, bicarbonates, hydroxides, and small percentages of other basic elements. The determination for alkalinity is made in two steps, the same sample being used for both. Fifty (50) ml. of the sample is measured into a white porcelain casserole and 4 drops of phenolphthalein indicator is added. If the sample becomes colored, hydroxide or normal carbonate is known to be present. N/50 sulphuric acid is added slowly from a graduated burette until the sample becomes colorless. The number of ml. of N/50 sulphuric acid used in the titration multiplied by 20 will give the resulting alkalinity for phenolphthalein in parts per million and in terms of calcium carbonate. Some chemists prefer to speak of this first step in titration as the test for causticity and the second step in titration of the sample, when preceded by step one (1), as the test for alkalinity.

After titration for causticity or phenolphthalein alkalinity has been completed 3 drops of methyl orange indicator is added to the sample. Normal carbonate, bicarbonates, or hydroxides will turn the sample yellow if they are present. N/50 sulphuric acid is added to the sample until the color of the solution changes to a faint pink. As soon as the sample turns from a pure yellow, the endpoint has been reached. The methyl orange or total alkalinity is equal to the number of ml. of N/50 sulphuric acid used in making both determinations, multiplied by 20. The first titration results are recorded as

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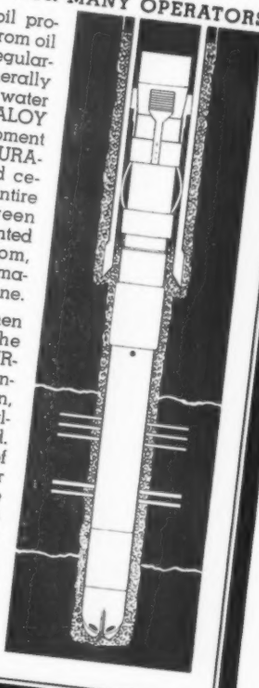

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the P reading and the results of the final titration are recorded as the M reading. The M reading always is greater than the P reading because the P reading is always included in the reading for M.

In making the tests for alkalinity of boiler waters that are highly concentrated, an aliquot portion of 50 ml. of the sample may be used. If 25 ml. of the sample is used, each ml. of acid is equal to 40 p.p.m. alkalinity expressed in calcium carbonate. If 12.5 ml. of sample is used, each ml. of acid is equivalent to 80 p.p.m. of alkalinity as $CaCo_3$.

In boiler water control it is necessary to convert the total alkalinity expressed as calcium carbonate to alkalinity as sodium carbonate by the formula: Calcium carbonate $\times$ 1.06 = sodium carbonate.

TABLE 1

Relationship between causticity and total alkalinity in the presence of hydroxide, bicarbonate, and carbonate

Titration results	Value of radical when expressed in terms of calcium carbonate		
	Hydroxide	Bicarbonate	Carbonate
P equals 0	0	M	0
P is less than ½ M	0	M—2P	2P
P is more than ½ M	2P—M	0	2 (M—P)
P equals ½ M	0	0	2P
P equals M	M	0	0

Acidity

Free carbon dioxide, mineral acids, and salts that hydrolize are represented by the acidity of a natural water. The determination of acidity is made by titration with N/50 sodium hydroxide solution. The titration is made with phenolphthalein as an indicator.

In making the determination for total acidity, 50 ml. of the sample is measured into a white porcelain casserole. Ten drops of phenolphthalein indicator is added and N/50 sodium hydroxide is then added drop by drop until the solution turns pink. The number of ml. of N/50 sodium hydroxide used, when multiplied by 20, gives the total acidity in p.p.m. expressed in terms of calcium carbonate.

Hydrogen Ion Concentration

When the hydrogen ion concentration determination is made colorimetrically, indicators whose colors in solution characterize the concentration of hydrogen ions satisfactorily are used for most control testing. If prepared standards are used for colorimetric determination, directions are usually supplied by the manufacturer. Colorimetric results are expressed in terms of pH.

The pH value of a water expresses the degree of ionization and not the quantity of material present. When using the pH scale of expression, the values from 0 to 4.3 indicate the acid zone; the neutral zone lies between 4.3 and 10.0, and the alkaline zone ranges from 10.0 to 14.0. If the boiler water is maintained at a pH of about 9.6, corrosion will be reduced.

Chlorides

After the phenolphthalein and methyl-orange alkalinity tests have been made, 5 drops of potassium chromate indicator solution can be added to the sample used for those tests. The potassium chromate solution will turn the sample a bright yellow color. Titration of the sample is accomplished by adding silver nitrate, 1 ml. = 1 mg. Cl, slowly from a graduated burette, constantly stirring the sample, until one drop changes the color to a pink or faint red. The first definite pink or faint red color remaining permanent on stirring should be taken as the endpoint. The addition of too much silver nitrate will cause a deep brick red color to develop, and care must be exercised in taking the endpoint properly.

The number of ml. of silver nitrate used in the titration, multiplied by 20, will give the chlorides in p.p.m.

To conserve on acid when testing boiler waters or natural waters that have a high chloride content, it is customary to dilute an aliquot portion of a 50 ml. sample with distilled water.

It is necessary at all times that the liquid titrated be 50 ml. If 25 ml. is combined with 25 ml. distilled water for the sample, the number of ml. of silver nitrate used should be multiplied by 40; if 12.5 ml. is used with 37.5 ml. distilled water, multiply the number of ml. of silver nitrate used by 80, etc.

The concentration of chlorides is a very important factor in boiler operation. The tendency toward foaming and priming increases with an increased concentration of soluble and insoluble susbstances. The concentration of these substances is controlled by the percentage of blowdown, and the blowdown is in turn controlled by the chloride test.

Sulphates

The tetrahydroxyquinone method may be used to analyze boiler waters having a sulphate ion concentration of more than 100 p.p.m. The temperature of the sample during the test should be below 90°F. and 25 ml. of a clear sample should be measured into a 150 ml. Erlenmeyer flask. If the sample contains between 100 and 700 p.p.m. sulphate, a full 25 ml. of the sample is used; however, if the sample contains more than 700 p.p.m. an aliquot portion is taken and diluted with distilled water to the 25 ml. required for the test. Add 2 drops of phenolphthalein indicator and titrate with N/50 hydrochloric acid until the sample is neutralized to the P point described under testing for alkalinity.

Measure 25 ml. of ethyl alcohol or of alcohol denatured by formula No. 30 and add to the sample. Introduce 0.20 g. of tetrahydroxyquinone potassium chloride mixture with a small cup, which has been provided for that purpose. Swirl the flask until all the mixture is dissolved and the solution takes on a deep yellow color. Titrate with N/40 barium chloride solution, constantly swirling the flask until a brown color begins to form. A brownish color indicates the approach of the endpoint and the barium chloride solution should be added one or two drops at a time, swirling the flask after each addition, until a permanent pink or rose-red color appears.

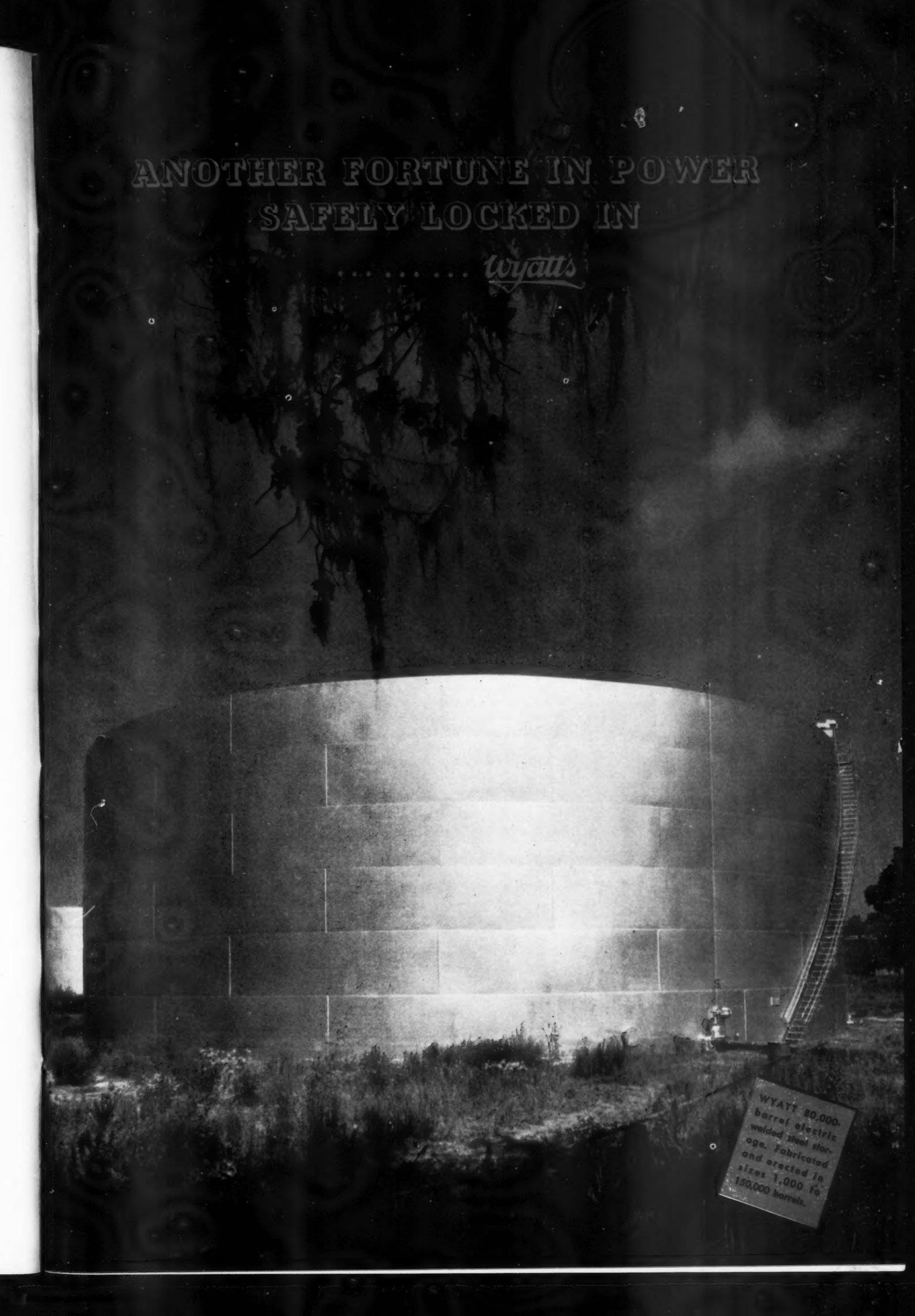
Using a 0.1 ml. blank the results are calculated from the formula:

(ml. $BaCl_2$ solution — 0.10) $\times$ 71 = p.p.m. $NaSO_4$ when a 25 ml. sample has been used. When an aliquot portion of the sample has been taken, the appropriate factor may be substituted in the above formula.

Ions found in boiler water, with the exception of phosphates, have little effect on this titration. If the phosphate ion concentration falls within the ranges shown in Table 2, the blanks indicated should be substituted in the formula given above.

TABLE 2

PO_4, p.p.m.	Blank
1 - 25	0.1
25 - 50	0.3
50 - 75	0.6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Deepening and Completing a Well in the Lisbon Field, Louisiana—A Study in Modern Coöperative Practice

Part 8 (Concluded)

By PAUL D. TORREY, Geologist, The Sloan and Zook Company
and
FRANK H. MILLER, Petroleum Engineer
Lisbon Exploration Company, Inc.

IT should be borne in mind, however, that all the figures in Tables 37 and 38 are predicated on a pay thickness of 10 ft. and the occurrence of gas and distillate in the reservoir. Should the pay section thicken or should it be found to be oil-bearing in other parts of the field the spacing pattern undoubtedly could be adjusted to smaller units and still result in profitable operation. The values assigned to the gas and to the distillate are fairly common "going" prices in north Louisiana at this time (February, 1940). Variations in the price structure will obviously have a direct bearing on the returns that may be anticipated.

Assuming a maximum recovery of condensate of 160,064 bbl. from a 640-acre unit and an average production of 100 bbl. per day it would require only about four years and four months to deplete the reservoir under a spacing unit of this size. This time figure is not reliable, however, as the recovery of condensate will decrease as the recycled gas becomes leaner thereby prolonging the productive life. Furthermore, it should be recognized that, although an estimate has been made of the gas reserves and their gross value, with the application of a pressure maintenance system, much of the gas will be left in the reservoir after the greater part of the condensate has been recovered. Consequently, it is urged that a decidedly deferred value be placed upon the gas reserves.

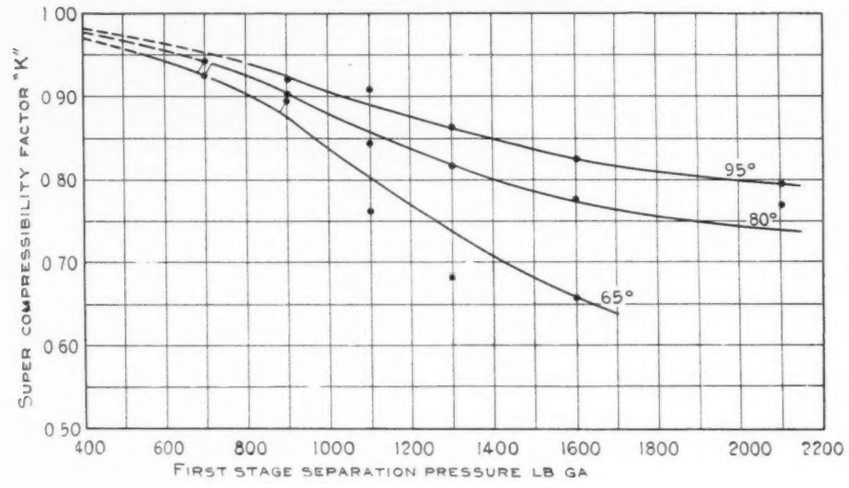
Photographs and biographical sketches of the writers of this article can be found on page 155 of the February issue of *The Petroleum Engineer*, in connection with Part 1.

Some income, in all probability, will be realized from the sale of gas for repressuring purposes, but it seems likely that the main part of the gas content of the reservoir eventually must be disposed of elsewhere.

If gas should be taken from the Vaughn well at a rate of 5,000,000 cu. ft. per day for experimental repressuring purposes for a period of 90 days, the equivalent of about 47 acres of the Vaughn sand reservoir will be depleted.

The question may be raised properly as to whether effective drainage can be obtained with the wide well-spacing pattern suggested. Although actual permeability tests were not made on the Vaughn sand, there is every reason for believing that the permeability is quite high inasmuch as the Vaughn well began to produce without swabbing after the casing was perforated and the mud displaced by water. The indicated high permeability would favor a wide well-spacing pattern, and with a pressure maintenance plant in operation it would appear likely that a high degree of recovery might be anticipated. It is, of course, true that a closer well spacing might promote a greater recovery, and this is particularly true should the Vaughn sand prove to be oil-bearing in other parts of the area. In those parts of the field, however, where gas and distillate will be found in the Vaughn sand, and with no greater thickness of pay section, the recovery data herein presented are self-explanatory insofar as the economics of closely spaced wells are concerned.

Fig. 16. Supercompressibility of gas at first-stage separation pressure



Methods for Increasing Oil Recovery

Methods for increasing oil recovery in the Lisbon field should include the repressuring of the Pettit lime with gas from the Lower Marine sands, the maintenance of pressure in the Vaughn sand and other Lower Marine sands that may be productive in the area, and the extraction of natural gasoline from the gas produced from the Vaughn sand and from the recycled gas produced from the Pettit lime wells. These various operations are to a certain extent related and dependent upon each other, but owing to the lack of information regarding the extent of the productive area of the Vaughn sand it has seemed desirable to consider each separately.

Should the Vaughn sand or other Lower Marine sands produce over a considerable area and several productive wells be drilled, the following procedure should assure a maximum recovery from the field. After pressure-volume constants have been determined

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for the injection of gas into the Pettit lime and the average separation pressure established that will provide gas for repressuring at a pressure suitable for introduction into the Pettit, a high-pressure absorption plant should be installed for the recovery of natural gasoline. After several Vaughn sand wells are drilled there should be considerable gas available in excess of that required for repressuring the Pettit lime, and this gas should be used for the maintenance of pressure in the Vaughn sand. To operate a pressure-maintenance plant without excessive cost will require an initial separation pressure of about 2000 lb. per sq. in. inasmuch as the cost of compressing the gas from atmospheric pressure to the pressure required for pressure maintenance would probably be prohibitive. In order to assure effective recovery of condensate, it will also be necessary to run the gas through a high-pressure absorption plant before it is returned to the Vaughn sand. Probably one central gasoline plant would suffice for pressure maintenance in the Vaughn sand and for the gas taken from the Vaughn sand and used for repressuring the Pettit lime. The gas produced from the Pettit lime wells likely may be quite rich in natural gasoline, and with any appreciable volume of return gas available a low-pressure gasoline extraction plant should probably be installed. The tail gas from the low-pressure gasoline plant could then be compressed and recycled into the Pettit lime so that in due course of time only a moderate withdrawal of gas from the Vaughn sand will be required for repressuring the Pettit lime.

Gas Repressuring the Pettit Lime

a. Preliminary tests. Before a definite repressuring program is adopted, preliminary tests of injection volumes and pressures should be made on representative Pettit lime wells. These wells preferably should be situated in the higher structural part of the field and in areas of low bottom-hole pressure. A high-pressure regulator and a pressure gauge should be installed on each line to the various injection wells just beyond the manifold leading from the first separator, and a high-pressure orifice meter should be set at each well. Inasmuch as the gas from the first-stage separator will be quite high in condensable fractions and as a measure for protecting the casing, each injection well should be equipped with tubing on the lower end of which a hook-wall packer should be set. All lines and other fittings should be capable of withstanding pressures of 2000 lb. per sq. in. It is quite possible that after actual injection tests have been made it will be determined that high-pressure equipment may not be required, but in the beginning it seems desirable to take all precautions necessary to insure that the gas is properly injected and that the tests conducted on the several wells be uniform.

Bottom-hole pressure tests should be made on wells adjacent to the experimental injection wells before any gas is introduced, and at periodic intervals thereafter as conditions may justify. An accurate daily record of production from each adjacent producing well should be kept. Should it appear from production gauges and from bottom-hole pressure tests that the gas is moving more rapidly in one direction than in others such inequalities in distribution should be corrected by back-pressuring the wells so affected. Low injection pressures should be used initially, and after the lowest possible injection pressure has been established, the pressure may be increased, in increments of from 100 to 200 lb. per sq. in., until the original bottom-hole pressure is approached or until there is evidence that the gas may be bypassing. The gravity of the oil produced in the experimental area should be checked at frequent intervals and samples of the gas from the producing wells procured for gasoline content tests.

b. A plan for repressuring. After injection pressure-volume constants have been determined and the effects of the repressuring tests ascertained, should these prove to be encouraging, plans can then be made for a large-scale repressuring program for the field. The sites of the permanent injection wells and the allocation of production present a very important problem. It will doubtless be found that injection rates for constant pressures throughout the system will vary from well to well; for this reason uniform volume of injected gas is far more important than the maintenance of a uniform pressure. By following this procedure an equal distribution of gas through each intake well can be maintained, by adjusting the injection pressure to conform to formation conditions; thus a uniform movement of gas through the lime will be provided from each point of introduction.

It is desirable that the gas first be introduced in the highest structural wells in the field. The introduction of the gas into the lime at down-dip locations is contrary to the natural relationship between gas and oil in a reservoir, and likely may be responsible for serious bypassing as the gas will naturally move up-dip. If the gas is introduced in the north wells of the field it is probable that very little gas will escape farther north owing to the thinning-out of the formation in this direction, and all pressure effects will therefore be exerted southward. With proper injection of the gas under controlled pressure and volume a gradually expanding gas cap should be formed in the higher structural areas; provided the fluid levels of the producing wells farther down the dip are properly controlled there should be no fundamental reason why they may not be brought back to flowing production. The success of this project will depend in large measure on the care with which it is supervised. If the introduction of gas or the production of gas becomes uncontrolled, which may readily occur when variable conditions of permeability exist, disastrous bypassing may result. Uniformity or injection and of expansion under pressure throughout the pay are essential.

The inclusion of propane, butane, and some pentane with the injection gas should have a decidedly beneficial effect. These compounds are very soluble in crude oil and will serve to increase the gravity and lower the viscosity. In the liquid form, they are excellent solvents for the heavier hydrocarbons, and it has been demonstrated in numerous experimental tests that they have an actual scrubbing effect.

It should be obvious that the first effects from the repressuring program will be noted in the producing wells nearest the injection wells, and by the same token these wells will be the first to be depleted. When such producing wells reach the stage where they will produce very little oil and essentially all gas, they can then be converted into injection wells, the original injection wells shut in, and the repressuring program thus further expanded in a southward (down-dip) direction. It is obvious, unless the repressuring program is properly conducted and supervised, that inequalities in production between various properties will develop, and that unless these are corrected so each operator can be assured of his fair proportion of the ultimate production, little support can be obtained for systematic repressuring. The ideal approach to the problem would be to allow complete unitization of the field, but at the present time this does not appear feasible owing to differences in recovery and remaining oil reserves throughout the field as well as to the multiplicity of operators and royalty owners. Some plan must be adopted, therefore, which will provide that each operator shall obtain his fair propor-

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• *The Petroleum Electric Power Association is the outgrowth of a desire on the part of Electric Power companies to render greater service, through cooperative effort, to the Petroleum Industry.*

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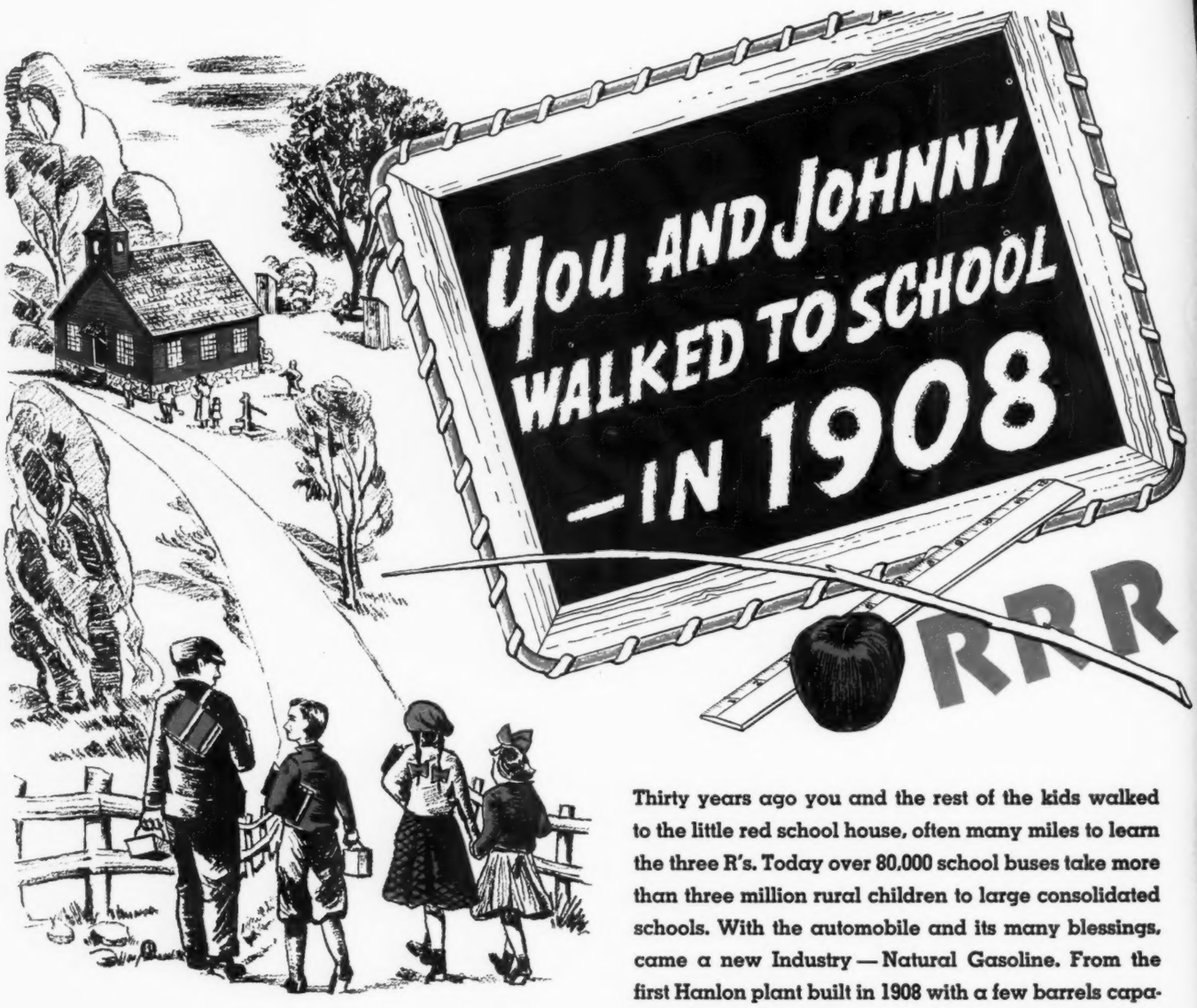

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tionate share of oil recovery in relation to the oil originally existing under his property.

At the beginning of the permanent repressuring program the operators owning the injection wells should be compensated for the salvage value thereof, and as most of these wells will be on 20-acre units, arrangements should be made for a 40-acre production allowable for the remaining well on the 40-acre tract. The selected injection wells should be equipped and operated under competent engineering supervision. The initial cost of installation, the expense of operation, the payment of salvage value for the selected injection wells, and the cost of the gas employed for repressuring should be borne by the operators immediately benefiting from the project through some form of production assessment. As the effects of the repressuring program expand into other parts of the field, all operators so benefited should share in the expense.

Some of the conditions in the Pettit lime that will have a direct bearing on the success of a repressuring program have been mentioned earlier. It may be pointed out that certain of the reasons that have been responsible for poor natural production by flowing and pumping will promote the application of secondary recovery methods. Some of these are:

1. Low average permeability, which would serve to promote a uniform movement of the injected gas through the lime.
2. Original undersaturation of crude oil by gas, combined with low permeability, has resulted in ineffective drainage, thus leaving considerable oil in the formation.
3. Absence of water in the formation, thereby eliminating the troublesome problem of emulsions.

For the purpose of studying the possibility of a repressuring program in the Lisbon field and the equitable distribution of costs and production allowables, statistical information was assembled pertaining to original oil content, oil recovery, percentage oil recovery, and percentage oil remaining. These data were based upon a careful statistical review of production from the field to January 1, 1940, and upon a study of the characteristics of the formation for each 40-acre unit of the field. Some of the constants used and some of the general deductions obtained from this investigation are given in Table 39.

The constants employed in Table 39 are weighted averages of core analyses and formation records throughout the field. Although the core data are by no means complete, they are fairly representative and it is probable that more complete information would not alter these figures to any appreciable extent. It is probable that between 3,000,000 and 4,000,000 bbl. of additional oil can be recovered from the Pettit limes in the Lisbon field without any artificial stimulation of production; consequently, approximately 30,000,000 bbl. of oil will be lost unless some form of secondary recovery method is applied. Based upon past experience in gas-repressuring operations in many fields a further recovery of about 7,000,000 bbl. of oil might be obtained by effective secondary recovery operations. These assumptions are, of course, predicated upon systematic and carefully controlled injection of gas. Improper injection of gas in certain parts of the field actually might do more harm than good.

A plan whereby each operator will receive his equitable share of the oil proportioned upon original oil content, actual oil recovery, and oil remaining under each property, can be readily attained through a control of production allowables. At the beginning of the program, while gas is being injected into wells in the northern part of the field, the production from wells in this area should be curtailed in order to permit operators in the southern part of the field to attain approximately the same percentage of recovery. Curtailment of production in the northern part of the field for a temporary period would permit the gradual build-up of bottom-hole pressures until they would equal those now existing in the southern part of the field. This should, in turn, provide for a gradual increase in the height of the fluid level in the north wells and eventually bring them to a flowing stage. When the inequalities in the percent of recovery between the various properties in the field have been corrected by adjustments of the production allowables, then the entire future production can be based upon the effects of the gas repressuring; each operator will then obtain the yield of oil that the quality of his property and the efficiency of his production practice will permit.

It is estimated that approximately 14,000,000,000 cu. ft. of gas have been produced in the Lisbon field since its discovery. This, in large part, was gas that was in solution in the oil, there being no true gas zone in the field. It may never be possible to return an equal amount of gas to the Pettit lime; at an average injection rate of 5,000,000 cu. ft. per day it would require approximately 7½ years to return the volume of gas that has formerly been removed. If it were possible to effect a complete return of the gas volume extracted, on the basis of the reserves established in the Vaughn sand from the record of the Vaughn well, the equivalent of about 1465 acres of the Vaughn sand would be entirely depleted in order to supply the gas for this purpose. In all probability additional producing wells from the Vaughn sand will be required to supply adequate quantities of gas for repressuring purposes, or else the time required to bring the wells to a flowing stage will be prolonged greatly.

In order to be truly effective, bypassing of gas through zones of higher than average permeability must be avoided. This can be accomplished by a control of injection volumes and by selective back-pressuring of producing wells yielding too much gas. If the gas is ever permitted to channel through a zone of high permeability the effectiveness of the program may be defeated in the affected area, and certainly if the gas does get out of control, it will be difficult if not impossible to remedy the situation.

Pressure Maintenance

Attention has been called previously to the necessity of installing a pressure maintenance plant in order to prevent retrograde condensation in the Vaughn sand. The importance of an installation of this type will be far more apparent should oil be found in this sand at lower structural levels. It is more or less self evident that it may be almost impossible to pump wells profitably at a depth of about 8450 ft. after the bottom-hole pressure has declined to the point where flowing cannot be maintained. To obtain the maximum possible recovery, therefore, the flowing life of the wells must be preserved. In the light of our present knowledge the only way that this can be done to attain maximum ultimate recovery is by the maintenance of pressure in the reservoir, either by gas injection or by controlled water encroachment. In the case of the Lisbon field it seems likely that the withdrawals from the reservoir will be at too rapid a rate to permit the application of the second method; the first method is the only alternative.

TABLE 39

Geologic constants and summary of statistical production data for the Lisbon field

Average porosity of pay	19.5 percent
Average permeability of pay	54.0 millidarcies
Average saturation of pay	50.0 percent
Average thickness of pay	9.65 ft.
Estimated original oil content of field	47,186,110 bbl.
Actual recovery to January 1, 1940	7,395,473 bbl.
Estimated remaining oil content of field	39,790,637 bbl.
Percent oil recovery	15.67
Percent oil remaining	84.33

After a sufficient number of wells have been drilled into the Vaughn sand to provide information regarding the possible productive area and better establish the oil and gas reserves, it will be possible to select a well-spacing program that will assure profitable development. This having been done it will be necessary in most cases to unitize both the working and royalty interests in the spacing unit selected for the drilling of deep wells. As soon as a sufficient reserve is established by the drilling of additional wells one or more compressor units should be installed for pressure maintenance in the Vaughn sand. Additional units may be installed at a later time as increased production may demand. Inasmuch as the location of the Vaughn well will very likely not be adaptable to the spacing unit that may be selected it is suggested that this well might eventually be converted into an injection well for pressure maintenance.

Gasoline Extraction Plant

Little further comment should be required to emphasize the desirability of extraction plants for the recovery of gasoline from the Vaughn sand gas and from the gas that will come from the Pettit lime wells after repressuring is begun. Attention should be given to the possibilities of fractionating-off the octane content of the condensate and natural gasoline for the purpose of blending the octane with Pettit lime oil and thereby improving its quality.

Summary

In the installation of pressure maintenance and gasoline extraction plants the coöperation of the operators in the Lisbon field is essential. Several independent plants would serve merely to increase the cost and certainly would not improve the efficiency of operation. The data are too meager at this time to enter into a discussion of the economics of these installations. It has been the purpose of the last portion of this article to point out the losses in recovery that will result if such installations are not made. As the facts concerning the productive possibilities of the field are better established a committee of petroleum engineers representing the various operators in the field should be in a position to decide on the procedure and the installation of equipment that will result in the most effective and profitable recovery.

P 615.322

Restrictions Impede Progress of Arc Welding

By C. M. TAYLOR

Vice-President, The Lincoln Electric Company

IT is altogether absurd that a valuable and straightforward industrial process such as arc welding, which has already created tremendous industrial and social benefits, and which will create still greater advances in the future, should be held back by restrictions and regulations that contribute nothing constructive but only serve to impede progress.

The worst feature of all restrictions is that the public many times questions the reliability of welding. As J. F. Lincoln, president of The Lincoln Electric Company, pointed out in a recent article that was widely quoted, there is no mystery in welding. The properly trained and capable welder will consistently make welds stronger than the steel, just as properly trained and able machinists will consistently turn out work machined to the closest tolerances.

Does someone stand over the trained mechanic checking every nut he turns down to make a bolted connection? Is the trained riveter beset by checkers and inspectors on every rivet he drives? Is the trained machinist harassed by supervisors on every operation of his lathe? Are all these trained craftsmen required to pass a test at frequent intervals to qualify for work that they have been doing for years and for which their experience and ability make them fully capable? Is every single riveted and bolted connection individually examined, inspected, and tested?

Obviously, the answer to all these questions is "No!" Yet the present trend in arc welding is in that direction. So many codes, tests, inspections, provisions, restrictions, and regulations are being imposed upon the process that the benefits it inherently creates are being seriously affected. Arc welders are severely handicapped, not only by frequent interruptions to permit inspection of work in process but also by having to be qualified over and over again for a type of work for which they have previously been fully accredited.

There is no more justification for this state of affairs in welding than in any other craft or trade. In fact, there is far less justification. Good welders will consistently make good welds, exceeding the physical properties of the metal welded.

All these restrictions are due simply to misplaced emphasis and to misunderstanding of the basic principle of arc welding. The uninitiated automatically focus all their attention on the arc-welded joint as the crux of the problem just as though the properly welded joint could accomplish any more than make a strong connection, fully as strong as the metal connected. As a matter of fact a good weld—and good welds are consistently made by good welders—develops the full strength of the steel welded. This being the case, why look to the weld for problems that never exist in reality? Why should every weld be individually inspected and tested when the welder who made it is fully as competent in his work as the riveter or bolter is in his? And why, above all, should an experienced welder be required to pass test after test to qualify for work he has been tested for previously?

All these hindrances are poor practice and highly unfair to welders. Given proper electrodes and proper equipment, the experienced welder will invariably make good welds. He knows that his production of sound welds will enable his employer to advance through pronounced improvements and economies in operations. The good welder is usually a capable, conscientious worker upon whom all the inspection and qualification tests serve only to work hardship. He wants these restrictions removed in order that he may be free to do his work properly.

As long as these pointless restrictions and regulations remain, progress of arc welding will be retarded and the immeasureable benefits that it can and will create for industry and society in general will remain unattained.

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In actual operation, with the hydromatic brake mounted directly on the drum shaft, it took about 45 seconds to drop the empty blocks when pulling 90-foot stands of pipe, as compared to only 15 seconds with the hydromatic brake disconnected, or a saving of 30 seconds for each 90-foot stand of pipe when coming out of the hole—equivalent to 300 extra engine horse power!

Equipped with clutch lever at driller's control position, this Hydromatic Brake *can be disconnected at all times when coming out of the hole; and when lifting empty blocks, when going in the hole.* Greatly speeds up both operations and saves wear and tear on Hydromatic Brake, engines and entire equipment. The only rig with Hydromatic Brake clutch control at driller's position!

This rig, owned by Pettijohn Drilling Company of Los Angeles, made a round trip at 8300 ft. with 4½" drill pipe in 2 hours and 30 minutes with 2 Le Roi 350 H.P. Engines. Can you beat this!

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Running Tour
WITH MEN IN THE INDUSTRY

R. L. WALES, engineer for The Texas Company, has been transferred from Woodsfield, Ohio, to New Martinsville, West Virginia.

T. B. MALLOY, engineer, The Texas Company, has been transferred from Seguin, Texas, to El Campo, Texas.

C. C. BEEBE, superintendent for J. J. Deaner at Keensburg, Illinois, is now making his headquarters at Beardon, Oklahoma.

WILLS M. DECKER, engineer, Cities Service Oil Company, has been transferred from Hattiesburg, Mississippi, to Columbus, Texas.

RAYMOND RICE, engineer for The Texas Company, is now making his headquarters at Seminole, Oklahoma, having been transferred from Tulsa.

JOSEPH T. KING, president of the Kingwood Oil Company, Effingham, Illinois, died August 21 at Rochester, Minnesota. He was born in 1881 at Duke Center, Pennsylvania, and entered the oil business in 1905 as a driller with Smith and McCormick, Bartlesville, Oklahoma. In 1915 he and W. E. Wood formed the Kingwood Oil Company.

WILLIAM HOSKINSON, superintendent for the Magnolia Petroleum Company at St. Louis, Oklahoma, is now stationed at Oklahoma City.

K. H. SPOONER recently was made district geologist at Jackson, Mississippi, for the Atlantic Refining Company. He has been at Houston, Texas.

CHARLES E. KRAMPF has resigned as president and director of the Penn Valley Crude Oil Corporation and its subsidiary, the Indian Drilling Corporation, to devote full time to private interests as an independent producer. He will make his headquarters at Olean, New York.

KARL A. MYGDAL, geologist, has been transferred by the Pure Oil Company from Wichita Falls, Texas, to Fort Worth, where he will be in charge of the North Texas and West Central Texas area.

R. E. GRAHAM, Stanolind Oil and Gas Company, Longview, Texas, is now stationed in the Fort Worth office. He is now assistant division clerk for the Texas Panhandle and East Texas, succeeding **J. G. CROSSKILL.** The latter has been made chief division clerk.

J. B. ROGERSON, superintendent for the Atlas Pipe Line Corporation, Shreveport, Louisiana, has been transferred from that city to El Dorado, Arkansas.

CHARLES T. CONRAD, engineer for the Gulf Oil Corporation, is now making his headquarters at Tulsa, Oklahoma, having been moved there from Centralia, Illinois.

B. I. ROUTH has accepted an appointment as head of the Department of Petroleum Engineering, University of New Mexico, Socorro, New Mexcio. He formerlv was with Gulf Oil Corporation at Tulsa, Oklahoma.

W. W. RAND, geologist with Shell Oil Company, Inc., is now stationed at Tuscaloosa, Alabama.

C. J. JORDAN, petroleum engineer, Continental Oil Company, is now making his headquarters at Woodville, Texas. He formerly was at Meridian, Mississippi.

C. S. POTTER, superintendent of materials for the Lago Petroleum Corporation, who has been in the United States, has returned to Maracaibo, Venezuela.

FRANK ANDERSON, of United British Oilfields, Ltd., has returned to Trinidad after spending some time in the United States.

EVERETT N. VAN DUZEE has been made manager of the Louisiana division by the Shell Oil Company, Inc., to replace **SAMUEL F. BOWLBY,** who has been transferred to Los Angeles to become chief exploitation engineer of the California division of the company. Duzee formerly was division manager of production at Tulsa, Oklahoma. **B. DYKSTRA,** formerly chief exploitation engineer at Los Angeles, has been transferred to Bogota, Colombia, South America.

BORIS D. VISHANOFF, assistant to the chief geologist, Shell Oil Company, Inc., Los Angeles, California, has been transferred to San Francisco as executive assistant.

CARL STEHLE has joined the staff of Dominguez Oil Fields Company, Los Angeles, California. He formerly was a member of the field staff of Union Oil Company.

WALTER H. MORRISON has returned to his former post of Oklahoma division manager of production for Shell Oil Company, Inc. While **REID W. BOND** was absent in South America, Morrison served as Mid-Continent production manager.

CLIFFORD HORN has resigned from the staff of the petroleum research laboratory of the School of Mineral Industries, Pennsylvania State College, to become head of the petroleum department of Texas Technological College, Lubbock, Texas.

W. L. DAVIS, of the R. B. Moore producing interests, Bolivar, New York, recently was made a member of the advisory board of the Bradford District Research Group.

J. PAUL JONES recently was chosen secretary of the Bradford District Pennsylvania Oil Producers Association.

L. E. BRENKAMP, petroleum engineer, has been transferred by the Atlantic Refining Company from the East Texas field to Alice, South Texas.

J. L. BRUNS has been made division mechanical engineer by Shell Oil Company, Inc., and transferred from Midland, Texas, to East Texas.

SIDNEY T. COVELL, San Francisco, California, has been appointed manager of purchasing and stores by Shell Oil Company, Inc.

At the Oil Show four of line of newly-designed Bethlehem Pumping Units were shown in operation.

Really a 4-Star Special—these smoothly operating Bethlehem Pumping Units. Not only at the Show but also in the field. And just in case you were not at the Show you surely ought to have the "low-down" on the new Bethlehem line. Nowhere else can you find so many admirable features in pumping equipment.

Look at the design No unnecessary weight—Strength to spare at highly stressed parts—No welds at critically stressed sections—High samson post and ample clearance for well servicing—Central lubrication—Settling chambers in all gear boxes—Safety devices—Large diameter crankshafts—Even the belt guard has been designed to facilitate easy and safe removal of demountable rim on driver sheave.

And the construction Rubber-mounted connection of walking beam and pitmans to provide protection from well shocks on smaller units—All-welded base and samson post—Built-in true alignment of entire unit without the use of shims—All bolts locked with double nuts—Forged steel, heat-treated gears and pinions—Triple-locked counterweights, easily removable and adapted to lag or lead.

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51-DT-10RB	123-DT-14	123-DT-14L

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E. E. MICHAELIS, Salem, Illinois, has organized the Michaelis Drilling Company.

ROY S. SULLINS has returned to Houston, Texas, after spending a year in Syria and Iraq as a consulting mud engineer for the Iraq Petroleum Corporation.

J. W. CAIN, JR., graduate of the University of Texas, where he received a bachelor of science degree in geology, has joined the staff of the General Geophysical Company and is stationed in Louisiana.

FELIX GORDON, formerly assistant petroleum engineer for the Buffalo Oil Company in Southwest Texas, has been made production engineer to succeed **H. J. LORENZ,** who resigned to engage in consulting work at Tulsa, Oklahoma.

J. C. HAWKS, assistant engineer of the United Natural Gas Company's Pine Grove compressor station at Coal Hill, Pennsylvania, has been retired after 20 years' service.

JAMES O. LEWIS, of Dunn and Lewis, Tulsa, Oklahoma, is in Trinidad, British West Indies, on business.

ASA KING, who has been vice-president in charge of production for the Kingwood Oil Company, has been made president, a post made vacant by the recent death of **JOE KING.** The company is active in the Illinois Basin area.

VAL R. WITTICH, JR., 30 Rockefeller Plaza, New York City, has been made export representative for the Miller Sand Pump Company, Oklahoma City, Oklahoma.

R. T. GERMAN, field superintendent in West Texas for the Magnolia Petroleum Company, expects soon to transfer his headquarters from Odessa to Brownfield. The company is constructing a camp at the latter place and as soon as it is completed he will make the move.

FRED PHELPS, Tulsa, Oklahoma, has been made district geologist for Kansas by the Sunray Oil Company, having his headquarters at Wichita.

WILLIAM A. CLAIR, engineer, The Carter Oil Company, has been transferred from St. Elmo, Illinois, to Tulsa, Oklahoma.

RALPH C. YOUNG, representative for the Frick-Reid Supply Corporation, has been transferred from Tulsa, Oklahoma, to Wichita, Kansas.

L. G. (PAT) ROBINSON, California sales manager for Security Engineering Company, Inc., Whittier, has recently established his residence in Bakersfield, where the Security district headquarters for the San Joaquin Valley is situated. This move places Robinson on his old stamping ground. Prior to establishing the present district office, he was headquartered there as San Joaquin Valley manager. After

L. G. ROBINSON

serving the company for some months in this capacity, he went to Illinois as special factory representative. When the company established a district office at Centralia, Robinson moved southward to Houston. When Security's district office was established at Houston, Robinson returned to the company headquarters at Whittier, where he has been in charge of California sales. **JUD WILLIAMSON** continues as San Joaquin Valley manager.

MAX W. BABB, president of Allis-Chalmers Manufacturing Company, has announced the appointment of **F. J. GEIGER** to the position of assistant manager of the electrical department, in which capacity he will be in complete charge of sales and engineering at the company's Norwood, Ohio, plant. Geiger entered the employ of Allis-Chalmers in 1913 in its New York district office. **FRANK R. FREYLER,** now in the company's Philadelphia office, will be transferred to the Norwood plant to take over Geiger's former duties as assistant manager of sales. **E. C. GEORGE,** who has been acting as works manager of the Norwood plant, and **A. THORSEN,** who has been acting as assistant works manager, have both been officially appointed to those respective positions.

W. P. (RED) KNIGHT, well-known in oil equipment circles, has taken over sales representation in the West Texas and New Mexico areas for the Kibele Manufacturing Company, Dallas, Texas. Knight also will continue with his representation of the Rector Well Equipment Company of Fort Worth, Texas. Headquarters will be maintained at Midland.

C. E. SULLIVAN, vice-president and sales manager of The Foxboro Company, Foxboro, Massachusetts, announces the appointment of Bumstead-Woolford as exclusive sales representatives for the Oregon and Washington territory. The firm of Bumstead-Woolford was recently formed by **DALE BUMSTEAD** and **O. H. WOOLFORD,** both of whom have wide acquaintance and long records of experience in fields of industrial engineering.

RICHARD D. ROBEY, JR., general manager of the Robey Drilling Company, Tulsa, Oklahoma, was killed in an automobile accident at Mt. Vernon, Illinois, on August 19.

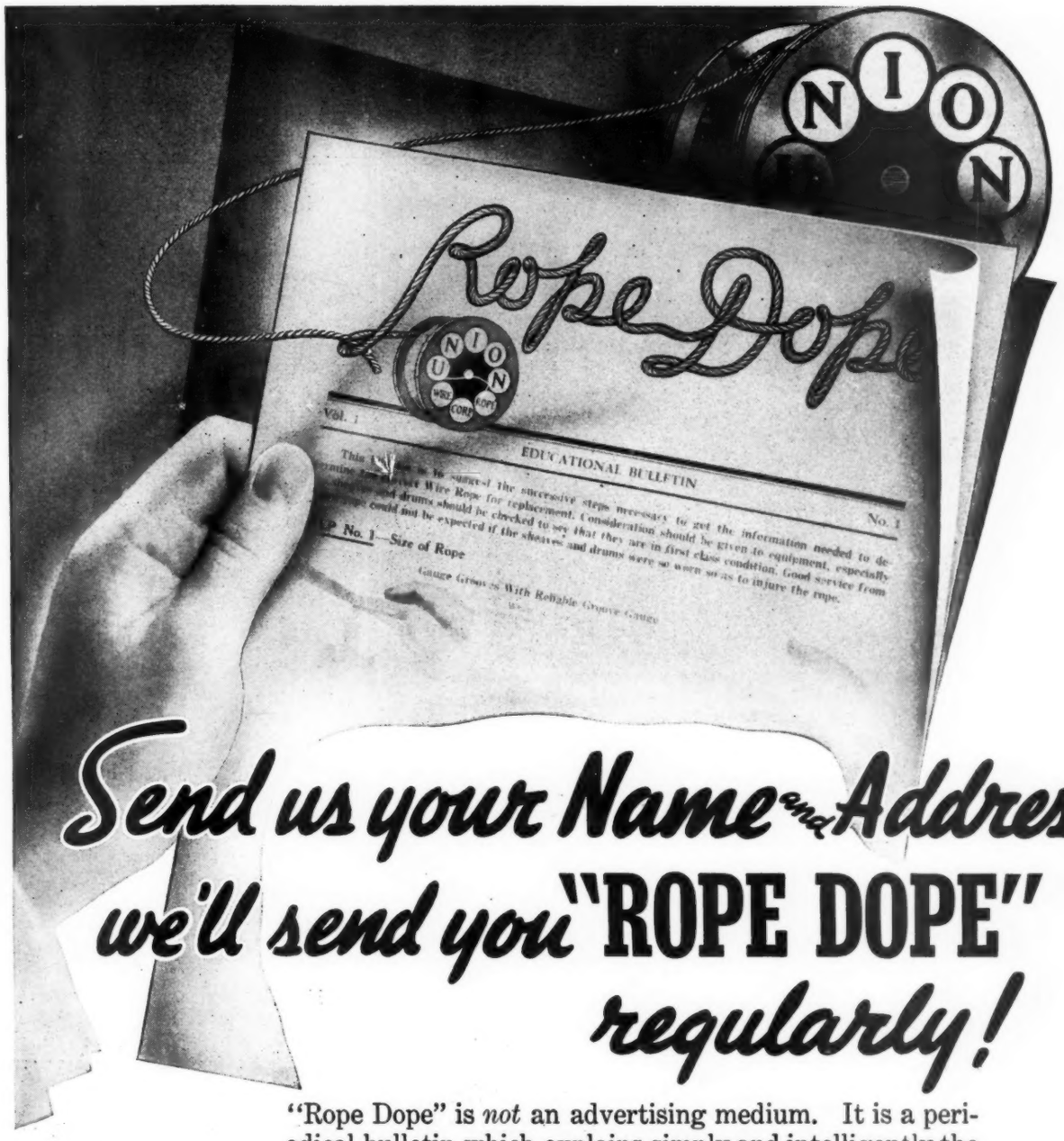
Robey was born in Hillsboro, Texas,

RICHARD D. ROBEY, JR.

May 30, 1902. He received a bachelor's degree in petroleum engineering from Oklahoma University in 1930.

His first affiliation with the oil industry was with the North and South Development Company at Luling, Texas. Later he joined the staff of Noble-Olson Drilling Company at Ardmore, Oklahoma, and when that company was dissolved he went with the Olson Drilling Company at Tulsa.

He formed the Robey Drilling Company in 1936.



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3

LAUGH WITH BARNEY

A rude and vulgar man is one who stares at a girl's figure when she's doing her best to display it.

* * *

Efforts of candidates to make themselves agreeable calls to mind the incident of the candidate who, becoming flustered, kissed the pretty mother and shoved a cigar into the baby's mouth. Upon due reflection it is just possible that the fellow was not so flustered after all.

* * *

A woman's ideal is sometimes shattered, but more often he is only broke.

* * *

A real nice girl is one who walks in her sleep when she dreams of auto rides.

* * *

"And how is your good wife, Sultan?"

"Oh, she's all right, but the other forty-nine are more fun."

* * *

Mistress: Marie, you were entertaining a man in the kitchen last night, weren't you?"

Marie: That's for him to say, ma'am. But I tried my best."

* * *

The doctor walked brightly into his waiting-room.

"Who's been waiting longest?" he asked cheerfully.

"I have," said the tailor, as he presented his bill.

* * *

Only First Nights

This amusing incident is related by a personal friend of the parties involved:

Not long ago the private and professional lives of a noted playwright and a New York stage actress became so involved they decided the only solution was matrimony.

The appointed hour for the wedding arrived. Assembled for the event were the creme de la creme of society and the theatrical world—but the bridegroom was missing.

A half hour passed and the bride was fit to be tied. Someone had the presence of mind to suggest opening the champagne and it wasn't long before the guests were feeling pretty hilarious.

Some two hours later the missing bridegroom appeared, much to everyone's relief. He wore an old, disheveled suit and obviously was sloshing to the gunwales.

"Oh, darling!" cried the distraught actress, "where have you been? This is our wedding night and look at you. You're not even dressed."

Drawing himself to his full, inebriated height, he informed her solemnly:

"Madame, I want you to know that I never dress except for premieres!"

—*Los Angeles Herald Express.*

* * *

Mabel: I hear that Stella has a propensity for petting.

Becky: Aw, all she's got is just an old-fashioned sofa like ours.

* * *

At the end of the fifth round the heavyweight staggered to his corner in a dazed and battered condition.

His manager approached him and whispered in his ear: "Say, Joe, I've got a great idea! Next time he hits you, hit him back!"

* * *

Typographical Error Department

And then there was the fellow who offered his new girl friend a Scotch and sofa.

She reclined.

* * *

Sandy was a leader of the kirk. His increasing redness of nose very much alarmed his brother elders, and a delegation waited on him to inquire the reason for the increasing color. Sandy explained thus: "It is glowing wi' pride at never putting itself in anybody else's business."

* * *

But Really!

Tommy Tulk caught this snatch of conversation from an adjoining ringside table:

First Jessie: Who's he dancing with? Point him out to me, will ya?

Second Dame: That's him right there. See? With that blonde job oozing from the brassiere?

First One: Is THAT him? That—that gland in sport shoes!

—*Los Angeles Herald Express.*

* * *

The old narrow trails where two cars could barely pass without colliding are happily being replaced by wide highways on which six or eight cars can collide at one time.

"Is your boy friend broadminded?"

"Yes, that's all he ever thinks of!"

* * *

A traveling salesman, in new territory, phoned the girl whose name had been given him by a friend.

"Are you free this evening?" he inquired sweetly.

"No," she replied, "but I'm available."

* * *

When Henry Jones and his bride registered at a hotel, the house detective thought the bride was a candy fiend because she kept yelling: "Oh, Henry!"

* * *

History records few women who laughed at the jokes of their husbands and those few had beautiful teeth.

* * *

Mose: I'm sho' glad my wife's built long and thin like a shoe-string.

Rastus: Why fo'?

Mose: Well, she don't keep de sun off de cawn when she's hoein' it lak a fat woman do.

* * *

A husband is an impossible combination of exasperating qualities that clutters up the house with pipes, fishing tackle and papers, and doesn't care a damn who marries William Powell.

* * *

Have you seen this chain letter that is currently making the rounds? Space does not permit listing of all the readers who were kind enough to contribute it.

Dear Friend:

This chain was started in Reno in the hope of bringing happiness to all tired business men. Unlike most chains, this does not cost any money. Simply send a copy of this letter to five male friends; then bundle up your wife and send her to the fellow whose name heads the list. When your name works up to the top, you will, in turn, receive 15,176 gorgeous girls.

HAVE FAITH

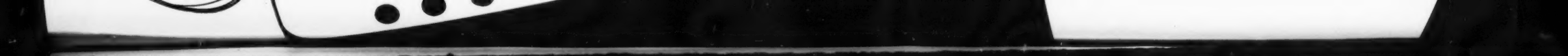
DON'T BREAK THE CHAIN

One man broke the chain and got his wife back.

* * *

"I was out driving with a drunk last night and he headed right for a telephone pole."

"The dog!"



BAKER
SAVE A WELL
CEMENT RETAINER

"For Friendly Service, and Dependable Products, Specify BAKER."

BAKER
CEMENT RETAINER

CASE STUDY NO. 406

PROBLEM: To squeeze off lower wet sand and protect upper oil zone

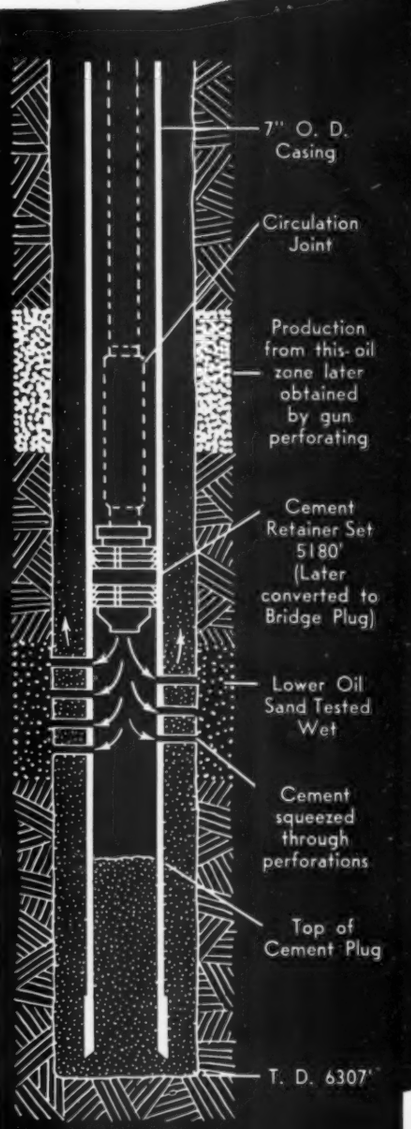
METHOD: Perform squeeze cement job with Baker Cement Retainer and then convert Retainer to Casing Bridge Plug

RESULT: Wet zone completely shut off; upper zone produced with no water

• DETAILS •

Field: Golden Meadows, La.
Depth of Well: 6307'
Depth Retainer Set: 5180'
Breakdown Pressure: 1400 #
Final Pressure: 2500 #

Quantity of Cement Mixed: 300 Sax
Number of Sax Put Away: 300
How Cement Discharged: through Perforations


7" O. D. Casing
Circulation Joint
Production from this oil zone later obtained by gun perforating
Cement Retainer Set 5180' (Later converted to Bridge Plug)
Lower Oil Sand Tested Wet
Cement squeezed through perforations
Top of Cement Plug
T. D. 6307'

Squeezing Off Lower Wet Zone with Baker Cement Retainer

IF you are confronted with water ...ms in your wells . . . problems which may be solved through the ...d proper placement of cement and acids . . . it will pay you to in... the Baker Cement Retainer. This device is daily solving many of ...l and unusual cementing, well repair, and well completion prob... confronting the industry today and it may be the solution to your ...lems.

Complete information concerning the design, construction and operation of the Baker Cement Retainer and its many practical field applications will be found on pages 239-249 of the Baker Section of the Composite Catalog; also, in Baker Broadcast No. 17-A, a comprehensive, 40-page treatise, which will be sent to any oil man upon request.

BAKER OIL TOOLS, INC.

Main Office and Factory, 6000 S. Boyle Avenue
P. O. Box 127, Vernon Station, Los Angeles, California

Central Division Office and Factory:
6023 Navigation Boulevard, P. O. Box 3048
Houston, Texas

Export Sales Office:
19 Rector Street
New York, N. Y.

A Case Study of an Actual Well Completion Problem Solved by Using the Baker Cement Retainer

IMPORTANT CEMENT RETAINER APPLICATIONS INCLUDE:

Squeeze Jobs • Recementing • Cementing Behind Sections of Pipe • Reducing Gas/Oil Ratios • Series Cementing • Plugging off Bottom Fluids • Plugging Back to Upper Zones • Testing Upper Cased Formations • As a Heaving Plug • As a Bridge Plug at any Place in Casing or Liner • Open Hole Acidizing • Open Hole Squeeze Cementing

BAKER CEMENT RETAINER

MACHINERY and EQUIPMENT

BS&B Tank Gauging and Thiefing Systems

TO make tankage as safe against the corrosive elements in gas and fluids in sour oil fields as the tubing, separator, well connections and piping to storage tanks, is one of the features claimed by Black, Sivalls and Bryson, Inc., Oklahoma City, Oklahoma, for their new BS&B Tank Gauging and Tank Thiefing Systems.

By using these devices the gauge tape and thief are "lubricated" into the tank without opening the tank to atmosphere. This results in keeping the

THE BS&B GAUGING & THIEFING SYSTEM

tanks under constant pressure, prevents evaporation losses, minimizes corrosion losses, and eliminates the necessity for gaugers to wear gas masks to protect them from the frequently poisonous gases from sour crude.

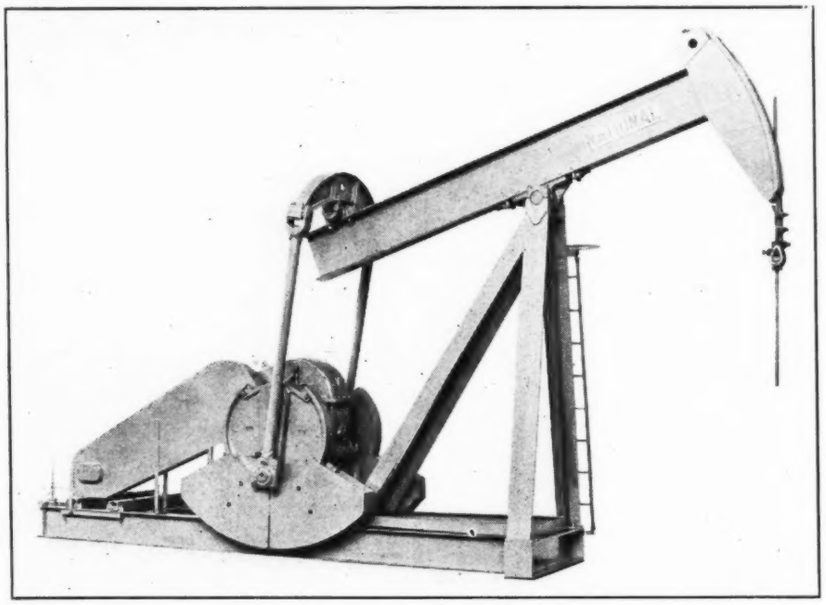
The device enables the operator to benefit from these advantages and still retain his present method of operation with regular gauge tapes and thiefs.

"It sounds almost impossible," says the manufacturer, "but gauging and thiefing operations can now be done without blowing a bit of pressure off the tanks, and with the conventional gauge lines and thiefs."

The accompanying illustration shows the system for both gauging and thiefing. Another model is designed for pressure gauging only.

National Supply Adds to Line of Unit Pumpers

THE National Supply Company, Toledo, Ohio, announces an addition to its line of Unit Pumpers. Designated as Type TUS 464-HD46TB, it is a twin-crank unit and is designed for the heavier requirements of



medium pumping service. It is made with a sub-base between the frame and the reduction gear to enable the cranks and counterweights to clear the derrick floor or a flat concrete pad.

General features of the new pumper are:

Arc-welded construction for maximum strength and rigidity with less weight.

Adaptability to either high-, medium-, or slow-speed prime movers, by means of reduction gear ratio and variation in V-belt sheaves.

Short frame base, to which an extension base with slide rails for various types of prime movers is bolted. This makes changes in the field comparatively simple and inexpensive.

Changing V-belt sheaves is facilitated by a tapered shaft that includes a locking device and a puller for easy removal.

Symmetrical construction prevents any tendency toward misalignment through unequal wear and distortion.

The A.P.I. peak torque rating is 113,000 in-lb. at 20 s.p.m.; reduction gear ratio, 29.6; A.P.I. safe load of walking beam, 15,100 lb.; maximum polished-rod stroke, 54 in. Regular equipment includes National Type B eccentric cranks, and National disk-type counterweights, which give infinite and continuously variable adjustability both in counterweight effect and in degree of lag and lead. The counterweights are of the one-piece type, locked securely in position on the outside rim of the crank. Adjustment is by power, hence convenient and safe because no lifting or manual handling is required.

A more complete description of the Type TUS 464-HD46TB Pumper may be found in Bulletin No. 267, copy of which will be sent on request.

Tops!

Top-quality steel wire, topnotch workmanship, well-balanced properties for rotary drilling — that's Yellow Strand. Add preforming, and it's "tops" in *limberness*, too — easy to string, to spool, to splice; highly resistant to kinking, whipping, fatigue, and drum crushing.

"Flex-Set" Preformed Yellow Strand Rotary Drilling Line tops your records in performance and in dollars-and-cents economy. Try it.

FREE! DRILLERS' WIRE ROPE HAND BOOK. 76 pages of valuable information for superintendents, drillers, engineers, purchasing agents. Write for Free Copy.

BRODERICK & BASCOM ROPE CO., St. Louis
Houston Branch: 1311 Palmer Street Houston, Texas

THE CONTINENTAL SUPPLY CO.
Mid-Continent and Rocky Mountain Distributors

Y-9

"FLEX-SET" PREFORMED YELLOW STRAND ROTARY LINES

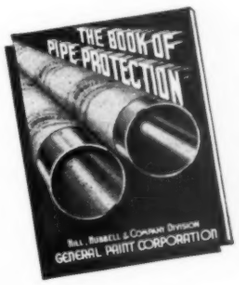
The HILL-HUBBELL "factory process" offers 2 IMPORTANT ADVANTAGES

EFFECTIVE PROTECTION and SPEED of INSTALLATION

10¾" O.D. Gas line, near Murrysville, Pa.

When your STEEL PIPE is Coated-and-Wrapped at the Mills by the HILL-HUBBELL "factory process" you obtain the highest degree of protective efficiency, and you can also lay your line faster. It comes ready to lay, which eliminates delays caused by bad weather. Because the entire job is done MECHANICALLY—INDOORS—all risks are eliminated and you obtain the most effective protection known today.

Buy STEEL PIPE MILL Coated-and-Wrapped at any of these Mills:
Jones & Laughlin Steel Corp.
National Tube Company
Republic Steel Corporation
Spang Chalfant, Inc.
The Youngstown Sheet & Tube Company



A request on your letterhead will bring a copy of "Pipe Protection" which describes our process in detail.

Schematic Construction of Specification TAX-I

GENERAL PAINT CORPORATION
HILL, HUBBELL & CO. • Division • Cleveland, Ohio
• EXPORT OFFICE: SAN FRANCISCO, CALIFORNIA, U. S. A. •

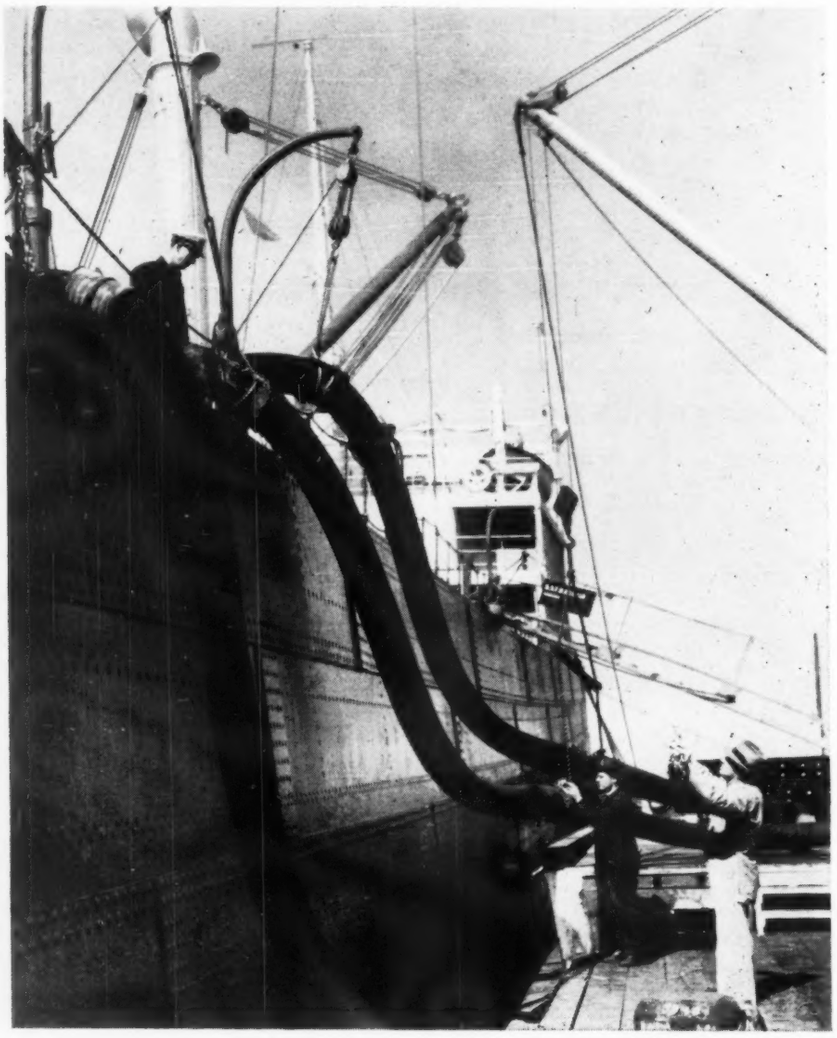
Hewitt Smooth-Bore Hose Speeds Tanker Loading and Unloading

RECOGNIZING that loading and discharging time is an important cost item in the operation of oil tankers and barges, many refiners and marketers have made careful studies of the performance of various types of dock and cargo hose.

Supplemented by laboratory tests, these studies have proved, according to the Hewitt Rubber Corporation, that smooth bore hose, with no exposed metal reinforcement on the inside, speeds-up the rate of flow by as much as 50 percent, dependent on the size of hose and the pressures or vacuums used. It is also established that the reduced weight and increased flexibility of the smooth "rubber" lined hose saves handling time.

Developed by the Hewitt Rubber Corporation, Buffalo, New York, the smooth bore hose shown in use in the accompanying illustration has been made possible through the use of synthetic, oil-proof rubber that will not swell or slough-off, and will not discolor petroleum products, it is stated.

It has been proved, the makers assert, that under the pressure normally used in tanker and barge loading, smooth bore hose reduces the flow resistance and the back pressure on the pump and reduces the pressure drop.

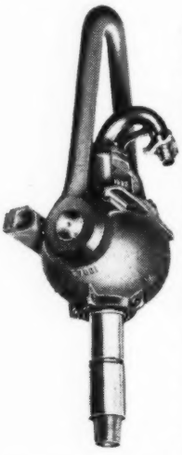


For regular continuous suction and discharge service Hewitt dock and cargo hose is built with two spirals of spring steel reinforcing wire imbedded within the hose wall. For normal discharge and moderate suction service, as in barge loading, etc., a slightly lighter construction of the same basic design is available. In both cases ends are enlarged, nipples are built-in, heavily reinforced, and permanently sealed against leakage with the patented Hewitt Dura-Bond process.

The regular heavy-duty type is available in 3 in., 4 in., 6 in., 8 in., and 10 in. I.D. The lighter construction is built in sizes 3 in., 4 in., 6 in., and 8 in. I. D. Both types are available in continuous lengths to 50 ft.

Wheland Swivel

DESIGNED for deep wells and heavy loads, the new Model E-7000 Wheland Swivel is announced by The Wheland Company, Chattanooga, Tennessee. The new swivel has a capacity of 464,300 lb. at 100 r.p.m. and weighs only 3400 lb. The swivel is carefully engineered for speed, performance, and flexibility, the manufacturer states.



Spring-loaded and lubricated, the swivel is equipped with washpipe packing, and includes many other features that are emphasized by the manufacturer in their Bulletin No. 167, which completely illustrates and describes the device. Among these features are oil-bath lubrication, manganese vanadium steel body, and large trunnions for bail cast integral with the body and practically in line with the main load bearing. All packings are automatically adjusted and lubricated through Alemite fittings. The lower stem lubricated packing is triple sealed and non-adjustable, there being no glands to adjust or nuts to work loose. The stem is removable without disconnecting the coupling. The long radius gooseneck permits the hose to hang in a natural curve without forming a reverse bend near the swivel connection.

Swing Joint for Steam Lines

FOR HANDLING steam pressure to 100 lb., a simple and effective swing joint has been developed. The sealing unit is a specially shaped and compounded rubber gasket. This gasket contains a percentage of very finely divided metallic lead, milled directly into the rubber. Because the lead acts as a lubricant, the joint turns freely under pressure. The gasket is expanded slightly by the heat, which helps to maintain a perfect seal.

By equipping steam lines with a swing joint of this type a flexible connection is maintained by the pipe to actuate movement of mechanism.

The joint is made of heavy bronze, weighs approximately 4½ lb., and is

available only in the ¾-in. straight style. The product is made by Patterson-Ballagh Corporation, manufacturers of rubber specialties and equipment requiring the use of rubber.

Further information may be obtained by writing the company at 1900 East 65th Street, Los Angeles, California.

Lightweight 60 Cu. Ft. Compressor

INGERSOLL-RAND Company has introduced a new two-stage air-cooled compressor that delivers 60 cu. ft. of free air per min. at a discharge pressure of 100 lb. It is known as the D-60. The unit is said to be inexpensive, thoroughly reliable, extremely compact, and light in weight.

Three types of mountings are available, all built around the same gasoline engine-compressor plant.

The push-about is mounted on roller-bearing, pneumatic-tired wheels. It is well balanced and can be easily

The new Ingersoll-Rand 60 cu. ft. push-about compressor

rolled on and off a truck. One man can handle it on the ground. A turtleback cover protects the compressor and engine from the weather and provides a means of locking the wheels against theft.

The Deluxe Model is a spring-mounted, high-speed trailer unit with tool boxes for carrying equipment built into the sides of the body.

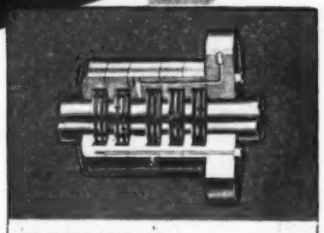
The Utility Model is mounted on a steel base and can be mounted directly on a service truck or built into the body.

Electric starting is available on the Utility and De Luxe mountings only.

A 6-page illustrated folder, Form 2688, contains a table listing the various air tools and the number of each that the D-60 will operate. This form is available from Ingersoll-Rand Company, 11 Broadway, New York City or any of its branch offices.

SEALING PRESSURES SINCE 1888

No packing bills on this INGERSOLL Compressor in 21 YEARS..



COOK'S METALLIC PACKING did it . . . Read what the Chief says . . . .

NEW —COOK'S Metallic Packings now available with COOK'S Graphitic Iron packing rings having preconditioned wearing surfaces which further reduce friction and prolong rod and packing life. Write for details.

Last Fall I had occasion to remove the air cylinder head from my Ingersoll Compressor to make an inspection. In doing this work it was necessary to remove the Cook's Metallic Packing from the 4½" rod. This packing had not leaked and I found only a few thousandths wear on the rod.

The packing has operated for 21 years and the rod has made 332,171,480 complete strokes in producing 7,906,440,000 cubic feet of compressed air.

In my opinion, Cook's Packings are the best on the market and have been my standard of good service for over twenty years.

THIS letter is one of hundreds in our "case history" files, all reporting years of service with never a penny for packing and rod maintenance. It explains the preference for COOK'S Packings that prevails in the industrial field generally. When ordering new engines or compressors, make sure you get the genuine—specify "COOK'S Metallic Packing" by name. For equipment in service, order from the equipment maker or from us direct.

"It Pays to use COOK'S METALLIC PACKING"

C. LEE COOK MANUFACTURING CO.
INCORPORATED
LOUISVILLE, KY.
New York Cleveland Los Angeles Baltimore Chicago Tulsa New Orleans San Francisco

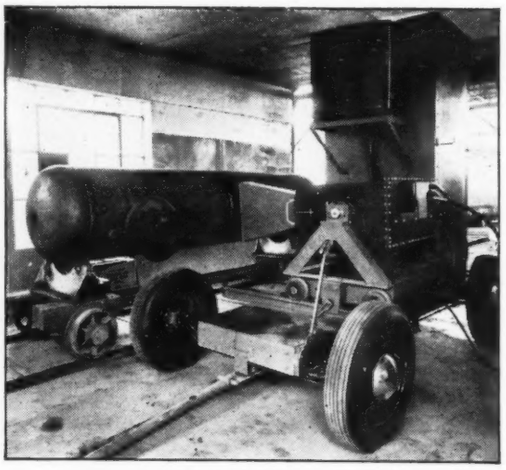
Chrome-Armored, Water-Lubricated Pump Bearing

BY heavy application of electrolytically-deposited chromium over a monel stainless sleeve that has been swedged into a vertical pump shaft, a new type of water-lubricated bearing has been produced by Peerless Pump Company, Los Angeles, California. The process has been perfected for use in deep-well vertical pumps. The pump shaft is armored with heavy chromium over a non-corrosive metal sleeve every 10 ft. These sections of the shaft operate within resilient cutless rubber journals, which are fluted and are non-revolvable. Any sand in the water flushes through the bearing. Because of the extreme hardness and thickness of the chrome, and its bearing contact with cutless rubber, no abrasion occurs, according to Peerless engineers. Heretofore, the use of a chrome surface was not satisfactory, due to its microscopic porosity, its thin wall and its eventual disruption from the carbon steel to which it was usually bonded, the manufacturer states. By the new Peerless process the chromium is electrolytically deposited to monel to a thickness of approximately three thousandths of an inch, which is more than 50 times as thick as ordinary automotive chromium plating and several times the thickness of chrome heretofore applied. In pumps placed under accelerated life tests, pumping water heavily laden with sand, the results indicate a shaft life of 27 times that of an ordinary carbon-steel shaft.

A bulletin describing this new chromium-armored bearing may be obtained by writing to Peerless Pump Company, 301 West Avenue, 26, Los Angeles, California.

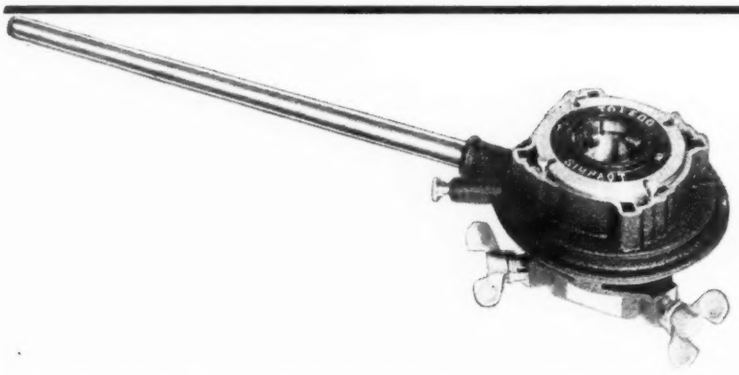
National Tank Installs New X-Ray Equipment

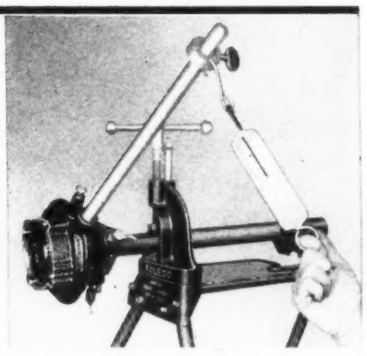
FOR quicker, better service to the oil industry, National Tank Company has installed in its Tulsa, Oklahoma, plant, a modern X-ray machine capable of penetrating and photographing thick steel plate. The unit, one of the most powerful in the Southwest, and one of two in Oklahoma, operates at a peak capacity of 220 kv. (220,000 volts).



National Tank Company's new X-ray machine

X-ray equipment is being used in industrial plants for testing welded seams, permitting visual inspection for the elimination of flaws in the welding of pressure vessels. A.S.M.E. construction codes require the use of X-ray in the inspection of vessels for certain uses, such as storage of lethal gases; X-ray of welded boiler drums is also required. National Tank Company states that the installation of this equipment enables them to supply pressure vessels for almost every purpose.





THE NEW "TOLEDO" SIMPACT 1" TO 2" THREADER - ONE SET OF DIES

— threads four sizes of pipe. Dies are high-speed steel and can be resharpened many times. Dies are backed by positive taper steps, assuring true taper and long life. No cams. Automatic drip oiling — oil pockets are filled and oil drips on dies and pipe as thread is being cut. Long lived, positive centering device. 24" tubular handle. You will be amazed at the easy operation and sturdiness of this new tool. Order today from your distributor.

THE TOLEDO PIPE THREADING MACHINE CO.
TOLEDO, OHIO NEW YORK OFFICE, 502 NO. 2 RECTOR STREET BUILDING

"TOLEDO"

BUY FROM YOUR LOCAL DISTRIBUTOR

Top view shows simple torque test. Simpact does pull easier.

Bottom view shows close-up of oil pockets. Oil drips on pipe as tool revolves.

Flashlight Bulb Extension

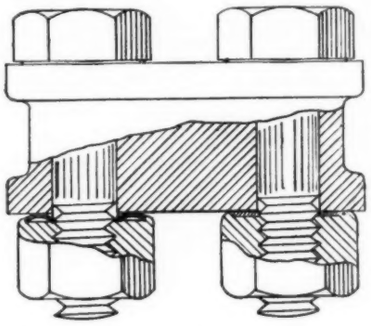
A FLASHLIGHT bulb extension for projecting light in hard-to-get-at places has been developed for drilling crews and tool pushers. To inspect the bearings of crown and traveling block sheaves, for getting under the brake drum of draw-works, and for making inspections of small-diameter pipe, checking the interior of mud pumps and other equipment, the device finds convenient use.

The extension is made in lengths from 6 in. to 36 in. and its plug is screwed into any flashlight with the bulb in the opposite socket. Being bendable it can go down into intricate mechanisms, through gearing, into tools and places where no ordinary light can reach, it is stated. A mirror attachment permits periscopic vision of sides of cylinder walls, etc.

Known as the Sierra Flashlight Bulb Extension, the device is made of special wire encased in high-grade aluminum-alloy tubing. It is made by the Sierra Aircraft Company, Sierra Madre, California.

An-cor-lox Lock Nut

A NEW self-contained, one piece, all metal, lock nut has been announced by An-cor-lox Division of Laminated Shim Company, Inc. This new device, known as the An-cor-lox lock nut, has several distinctive features that make it particularly interesting to builders of machinery of all kinds, the manufacturer asserts. It utilizes a new locking principle that permits, effective, positive locking of the nut to the bolt, not to the work, it is stated.



To apply, the An-cor-lox lock nut is simply spun on the bolt and drawn up to the desired degree of tightness. The nut locks itself automatically to the bolt. The arcuate-shaped metal locking ring contained in the bottom of the nut is expanded by the locking pressure into the root of the bolt thread and against the nut rim. This "lock joint" holds securely under all heat conditions and vibration, it is stated. No special length of bolt is required. An-cor-lox is perfectly adapted even to short bolts.

An instance of An-cor-lox convenience is seen in the fitting and adjustment of bearings and other parts. For the primary set-up, accurate fit can be obtained by merely spinning-on the An-cor-lox nut in reverse position—without locking. Then in the final set-up, the An-cor-lox lock nut is turned to its normal position and goes on the bolt for automatic locking.

An-cor-lox lock nuts are available in all standard sizes and in all metals. They may be obtained packed in standard packages, or in bulk in larger quantities. For further information regarding the new An-cor-lox lock nuts write to An-cor-lox Division, Laminated Shim Company, Inc., 64 Union Street, Glenbrook, Connecticut.

Above is illustrated how the "140" (one of several Cleveland Models) handles rough, rocky jobs

Geared to Field Requirements—

"CLEVELANDS"

Go ANYWHERE-ANYTIME and DIG

Your next job — where will it be? What kind of field conditions will be encountered?

Equip yourself with "Clevelands" and be **prepared.**

All 'round performers, these machines are geared to the job. The features necessary for superior performance under all conditions are built right in.

THE CLEVELAND TRENCHER COMPANY

"Pioneer of the Small Trencher"

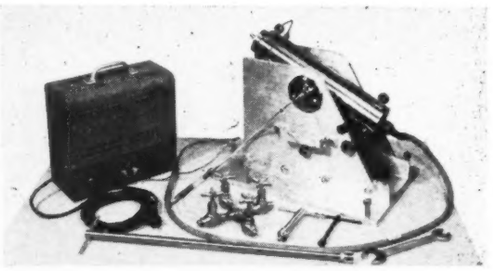
20100 St. Clair Avenue CLEVELAND, OHIO

Illustrated at right, an important Cleveland feature — Truck Speed Transportation on specially built trailers — Machines load or unload in about 15 minutes.

Humble Pressure Viscosimeter

ENGINEERING Laboratories, Inc., 610-624 East Fourth Street, Tulsa, Oklahoma, announces the first of a series of new testing instruments —the Pressure Viscosimeter, Assembly No. 1600, Type D.

The Humble Pressure Viscosimeter is a rugged and simple laboratory instrument designed to measure the viscosity of subsurface samples of oil from a small sample, and under varying conditions of temperature and pressure. The apparatus consists essentially of a removable, accurately bored, cylindrical barrel of ¼-in. nominal internal diameter, in which a closely fitting steel ball rolls through the oil with the barrel inclined at a definite angle. The ball makes contact at one end of the barrel with an insulated electrode, and actuates a buzzer. The length of time for the ball to roll the length of the barrel is measured by a stop watch.



The removable barrel is held in place in the cylinder by a nut in such a way that after the sample of oil has been placed in the viscosimeter, the barrel can be moved to allow the free circulation of oil through and around the barrel. In this manner, when the cylinder is turned on the trunnions, the ball rolls from one end of the barrel to the other and circulates the oil to insure proper mixing of the sample. The upper portion of the steel cylinder is enlarged and forms a tapered chamber that acts as a reservoir for the oil, and affords space for agitation to insure equilibrium between the gas and oil. After the oil sample has been circulated around the barrel, this sample is enclosed inside the barrel by a plunger on the upper end and a gasket at the bottom. With the cylinder turned in a position so that the top of the barrel is down, the ball will come to rest at the lower end of the barrel. As the cylinder is turned on the trunnion to the desired angle, the ball rolls through the oil at a speed that is a measure of the viscosity of the oil.

It is necessary to calibrate the instrument both before use and periodically by using several fluids, the viscosity of which has been determined by a calibrated Ubbelohde suspended level capillary instrument. The densities of the calibrating fluids are determined by a pycnometer. These calibration curves are plotted with the roll time, times the difference between the density of the ball and the density of the oil in grams per cc., as one coördinate and the viscosity in centipoises as the other coördinate. From these calibration curves, it is then a simple matter to determine the viscosity of a sample under any conditions of temperature and pressure.

The viscosimeter is connected to the sampler through a manifold assembly and the steel tube from the sampler flushed with the sample. The viscosimeter steel tube connecting the viscosimeter with the manifold as-

Is it true

what they say about B. H. Pressure?

It is a recognized fact that accurate Bottom Hole Pressure records are the most practical method of determining the productivity index of a single flowing well or of an oil field. *(Some states require this method of potential determination.)* Through the use of Subsurface Recording Instruments, tests can be exactly duplicated a month or a year later. Basic information obtained by the use of HUMBLE TYPE subsurface Recording and Sampling instruments will assist in determining:

Estimate of oil reserves. Presence and movement of gas cap. Amount of fluid to be lifted. Minimum flowing pressures. Specific productivity factor. Density of fluid column. Static fluid and oil levels. Gas-oil ratios, etc.

1¼" O.D. SUBSURFACE PRESSURE GAUGES—maximum recorder and clock recorder types. HIGH PRESSURE SUBSURFACE SAMPLER and the SUBSURFACE RECORDING THERMOMETER—all Humble Types, are manufactured, sold, and serviced exclusively by E. L. I.

All three instruments are sufficiently rugged to withstand the abuse of oil field use, and are not affected by the action of corrosive acids. Trained personnel is not necessary to operate these instruments.

The gauges measure pressures to an accuracy of 0.5% and with special precautions to an accuracy of 0.25%. Will measure pressures to 8,000 lbs., per sq. inch or higher.

WRITE FOR DESCRIPTIVE LITERATURE

World Wide Service

Engineering Laboratories, Inc.

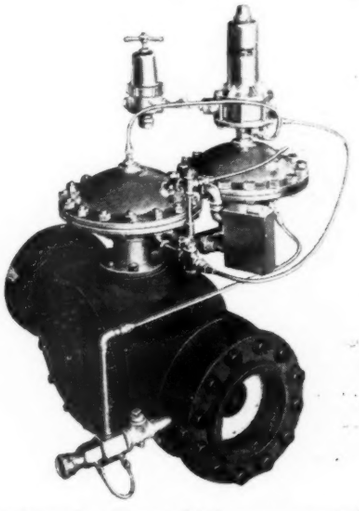
CONSULTING ENGINEERS AND MANUFACTURERS

TULSA, OKLAHOMA, U. S. A.

sembly and the manifold assembly are then evacuated. After evacuation, the sample is kept under more than the saturation pressure in the sampler and the manifold valve connecting the sampler with the viscosimeter is opened in order to fill the viscosimeter with a representative sample. The pressure in the viscosimeter is then increased to more than the saturation pressure and thoroughly agitated so that all oil will become completely saturated. The viscosimeter is then placed in a water-bath so that the temperature can be controlled. The pressure and temperature are regulated and the viscosity measured under the desired conditions. As the pressure in the cylinder is reduced by withdrawing quantities of oil and gas, the sample is agitated to insure equilibrium and other determinations made.

Automatic Loading for Emco High-Pressure Balanced Valve Regulators

THE Pittsburgh Equitable Meter Company, Pittsburgh, Pennsylvania, has announced the availability of a system that provides automatic



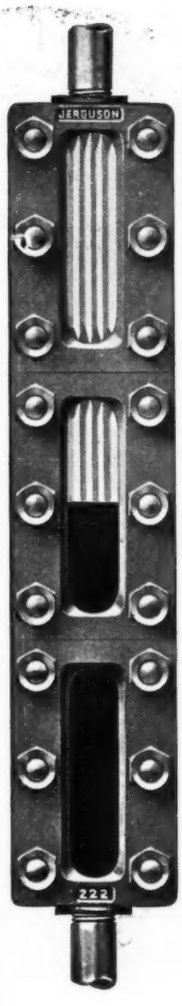
loading for Emco high-pressure, balanced valve regulators controlling outlet pressures in excess of 1 lb.

In this system, the main regulator is of the standard Emco high-pressure balanced valve design, fitted with a standard pilot loading head. To provide automatic loading (or boost) an orifice plate is used, set at the outlet of the main regulator.

As the flow rate increases through this regulator, the pressure differential increases across this orifice plate with the square of the velocity. This differential pressure is led by means of piping to a differential diaphragm head. This diaphragm head has mounted on it an Emco Type 39 pilot loading regulator, so connected to the differential boosting head that as the differential pressure across this head increases, the pilot loading regulator diaphragm is more heavily loaded. This has the same effect as increasing the control spring loading. Thus with increasing flow rate, the orifice differential increases, which in turn increases the loading on the differential boosting head. This results in an increased loading of the base pressure pilot regulator and, of course, raises the outlet pressure. To provide a maximum limit as a safety, i.e., a point beyond which the regulator can not boost the pressure, an Emco Type PR pilot loading regulator is set in series ahead of this Emco Type 39 pilot loading regulator.

The manufacturer calls particular attention to the fact that separate assemblies are used to make up the component parts in this system of loading. It is asserted that by using separate assemblies for the various parts, it is possible to adapt the new automatic loading system to existing regulators; also to Emco regulators now equipped with pilot loading heads. The actual arrangement of the parts can be varied so as to provide the most accessible and convenient installation or to conform with the dimensions of any vault or regulator house.

JERGUSON



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Because . . .

They are sturdy and withstand high temperatures and high pressures.

They are safe, dependable and easy to read.

They indicate unmistakably the liquid level in tanks, towers, stills, etc., because the . . .

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Jerguson Gages are best by every real test

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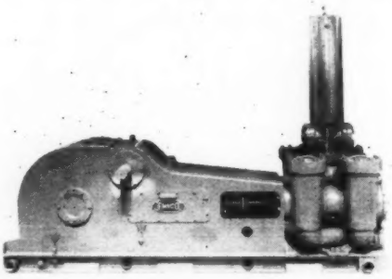
JERGUSON GAGE & VALVE CO.
89 FELLSWAY
SOMERVILLE MASSACHUSETTS

New Products Distributed by Bovaird Supply

A NEW product distributed by the Bovaird Supply Company, Tulsa, Oklahoma, is the Emsco Power Slush Pump. Emsco pumps are of all-steel construction with fabricated power end and cast-steel fluid end. A great saving in weight over conventional construction is effected, according to the manufacturer, without sacrificing strength.

The use of a cast-steel fluid end permits easy field repair by welding. Any fluid cut or abrasion, particularly of the cylinder or valve chambers, may be built-up and machined without the renewal of such parts.



Emsco Power Slush Pump

The fluid end is given a 3500-lb. hydrostatic cold water test and the equipment is recommended for operation at 2000-lb. pressure.

The pump comes in sizes 7¼ by 12 and 7¼ by 14.

Another new item of equipment distributed by Bovaird is the Veelos V-belt. This is an adjustable link V-belt adaptable to drives of all sizes. Every link is a master link.

The belt is quickly made endless around any drive and requires no disassembling of bearings or machine on drives using outboard bearings. It will

Veelos V-belt

operate on sheaves smaller than the minimum recommended for solid belts due to its great flexibility, the manufacturers state.

The Bovaird Supply Company is exclusive distributor to the oil industry in Illinois, Kansas, Oklahoma, and the Texas Panhandle for these two items of equipment.

"Sure I'm TOUGH-just like Patterson-Ballagh Protectors"

Tough only begins to tell the story. These Protectors are tough all the way through from skin to pipe. The highly developed Patterson-Ballagh process of compounding and curing the rubber assures uniform toughness throughout the cross-section. The amazing tenacity of the rubber offers tremendous gripping strength. They cling to the pipe as if locked, resist abrasion and retain their effective diameter for tens of thousands of feet of drilling. Avoid cheap substitutes and save money in drilling.

PATTERSON-BALLAGH CORPORATION . . . Los Angeles · Houston · New York City

Brewster 12-in. Streamlined Rotary

THE Brewster Company, Inc., Shreveport, Louisiana, is introducing a new 12-in. streamlined water well rotary. Although this small new rotary has been designed for, and is considered water well equipment, it is

ideal for any shallow drilling, with strength and stamina to handle 2500 ft. of 4-in. pipe easily, the manufacturer states.

The overall length of this rotary is only 55 in. and the extreme width of guard only 34 in. The skid width is 26 in. and overall height 15 in. Centerline to centerline is 28 in.

Alemite lubricated roller bearings are used on the pinionshaft and enclosed in a housing that can be easily removed for replacements.

The table has full 12-in. opening and turns on twenty-one 2-in. balls, Alemite lubricated. Gear reduction ratio is 5.4:1.

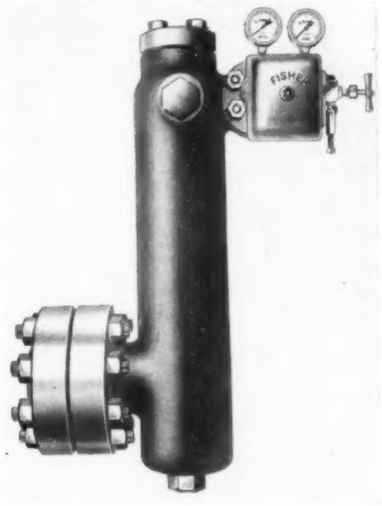
Electric steel is used in casting the bed and skids integral. The net weight of this new water well rotary is only 1490 lb.

Complete details and prices may be obtained from The Brewster Company, Inc., Shreveport, Louisiana.

High-Pressure Level-Trol

AN improved high-pressure liquid level controller, Type 246-H, is announced by the Fisher Governor Company, Marshalltown, Iowa. It is especially designed for high-pressure, wide-range service as a remote type liquid level controller when it is desirable to install the diaphragm control valve at some distance from the vessel.

The body of this new high-pressure Level-Trol is electric cast steel, series 2500 lb., A.S.A. rating—suitable for



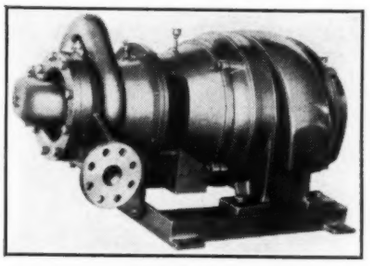
maximum cold working pressure of 4000 lb. Lower equalizing connection is 3-in. flange type; upper equalizing connection, 1-in. flange type.

The 3-in. by 18-in. Dowmetal float is supported by a chrome vanadium tungsten steel cantilever spring. The bearing is of the non-lubricating packless type. The connection for the assembly on the bottom of the cage member is a high-pressure hydraulic type. The complete unit includes a ¼-in. Fisher Type 77 auxiliary operating medium-pressure regulator, two operating medium-pressure gauges, and cooling fin assembly.

Allis-Chalmers Extends Line of Multi-Stage Unit Pumps

ALLIS-CHALMERS Manufacturing Company, Milwaukee, Wisconsin, has recently extended its line of multi-stage "SSUnit" pumps in which the motor and pump housings are bolted together for compactness. This includes a new two-stage pump with 4-in. suction and 2-in. discharge that can be rated to 275 gal. per min. against heads to 500 ft. at a speed of 3550 r.p.m.

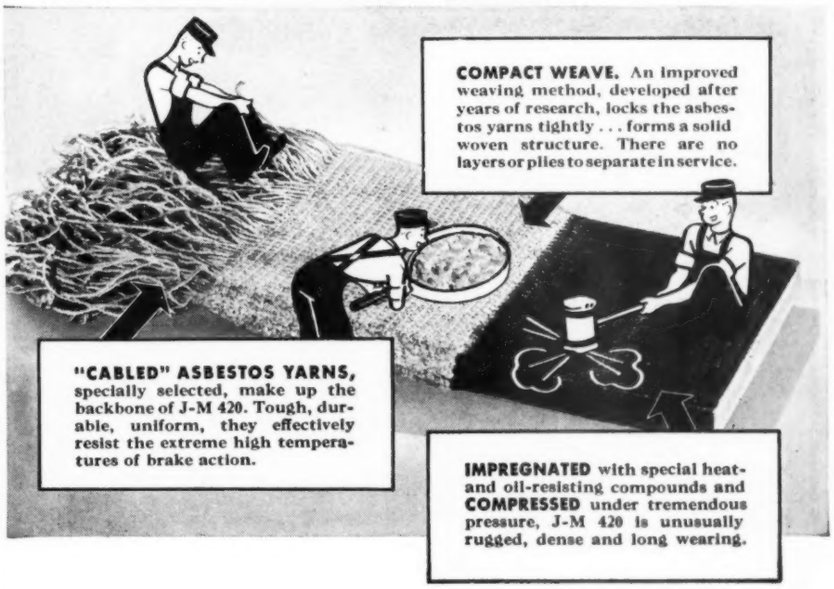
The new pump, like the company's smaller multi-stage pumps of this type, has cast-iron casing and cover, and is bronze fitted throughout. The im-



pellers are placed back-to-back to provide axial balance. The cover can be removed readily, permitting the inside parts to be removed without disconnecting the suction and discharge piping. The stuffing box on the pump is only subjected to suction pressure.

This unit can be supplied with either an open, splash-proof, totally enclosed or explosion-proof motor. It is suitable as a small boiler-feed pump, mine pump, or pipe-line pump. It can be used in humidifier work, air-conditioning service, oil loading, and many other small-capacity, high-pressure services. Bulletin B-6105 will be sent on request.

What makes J-M 420 a Better Rotary Lining?


COMPACT WEAVE. An improved weaving method, developed after years of research, locks the asbestos yarns tightly . . . forms a solid woven structure. There are no layers or plies to separate in service.
"CABLED" ASBESTOS YARNS, specially selected, make up the backbone of J-M 420. Tough, durable, uniform, they effectively resist the extreme high temperatures of brake action.
IMPREGNATED with special heat- and oil-resisting compounds and COMPRESSED under tremendous pressure, J-M 420 is unusually rugged, dense and long wearing.

WHEREVER used, J-M 420 Rotary Lining delivers these four important advantages:

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Higher braking efficiency, even at extreme temperatures caused by heavy loads . . .

Longer life, under any conditions . . .

Less rim scoring, making drums last longer . . .

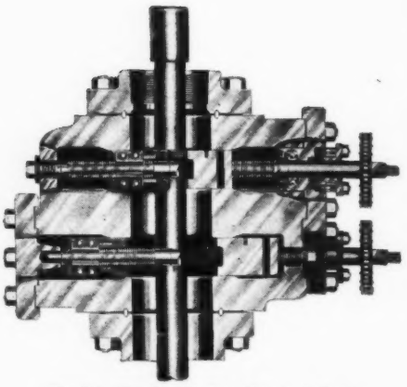
In every major oil field in the country, J-M 420 Lining is helping keep braking efficiency high, operating costs low. Owners, operators, drilling crews all agree, "You can't beat it for continued dependable performance on the job!" A tryout on your own rigs will convince you. For details, write for brochure FM-10A. Johns-Manville, 22 East 40th Street, New York, N. Y.

Johns-Manville 420 ROTARY LINING

Shaffer Double Cellar Control Gate

A DOUBLE cellar control gate has been designed by Shaffer Tool Works, Brea, California, for use when the vertical space available is so small that it is desirable to reduce even the very small space required for two single gates and the connecting spool between. The two ram compartments comprising the Shaffer Double Cellar Control Gate are constructed with the upper compartment having rams to close around the pipe and the lower compartment equipped with rams for a complete shut-off when the pipe is out of the hole. The vertical space required by the double gate is approximately half that required for two single gates and their connecting spool. The double gate itself is less in height than two single gates alone.

The rams in the upper compartment are self-centering and center small-size drill pipe in the bore of the gate as they close around it. They are made with protruding angular guides alternately top and bottom and as the rams move toward their closed position these guides engage the drill pipe and move it into a central position in the ram.



Shaffer Double Cellar Control Gate

The angular guides telescope into the opposite ram block, which permits the abutting faces of the ram blocks to seal perfectly. Ram rubbers may be either rubber or neoprene.

The upper compartment with the self-centering rams for closing around pipe has the end cover placed at the front face of the gate body. On the inside of this end cover are bosses for the reception of annular thrust ball bearings. These bearings are an important factor in reducing the friction that is caused by the end thrust on the collar of the operating screws caused by well pressure. The ram assembly in the upper compartment is removed from the front end, whereas the end cover for the removal of the ram assembly in the lower compartment is at the rear end of the gate.

Bolted to the front face of the gate are thrust plates with ball bearings for the operating screws of the lower gate. The extension of the operating screws of both the upper and lower compartments are on the same end of the double gate and remote control can be used in the same manner as when two gates are used.

The Shaffer Double Cellar Control Gates can be supplied in sizes from 6⅝ in. to 11¾ in., inclusive. Dimensions and weights will be supplied on request.

Air Hose for Excessive Hot Oil Service

RECOMMENDED for use where excessive hot oil conditions are encountered, The B. F. Goodrich Company, Akron, Ohio, announces the addition of a new air hose made with a synthetic tube and rubber cover. It is known as Type 54.

Laboratory tests indicate that the synthetic tube used in this construction should give two to three times longer service life when exposed to the same conditions as a tube made of natural rubber, the manufacturer asserts. The hose is built with a smooth green abrasion-resistant cover.

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FOR OIL FIELD SERVICE
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Whether for spudding, drilling, pumping (individually or from central power plant) generator service for power or lighting, the operator must give careful consideration to power units that are built to "take punishment." Continental Red Seal Engines can "take it," because they're built for it.
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Continental Motors Corporation

Pete Wallace of Link-Belt Visits South American Oil Fields

Fred "Pete" Wallace, oil industry manager for Link-Belt Company, with headquarters in Houston, Texas, left Miami, Florida, September 19, via Pan

FRED "PETE" WALLACE

American Clipper, for a two months' tour of active fields in Colombia, Venezuela, and Trinidad in the interest of Link-Belt oil-country chains and vibrating screens. This is Wallace's second trip into South American countries, having made an extended tour late in 1939. He plans returning to the United States in time for the A.P.I. meeting in Chicago.

Los Angeles Nomads Hold Barbecue

The First Annual Nomads' Barbecue was held by the Los Angeles Chapter at General Petroleum's barbecue pit near Brea, California, on September 11. About 300 were in attendance, more than 100 of whom were oil men from foreign fields.

After enjoying a steak dinner, games of skill were indulged in with prizes awarded to the winners. The prizes included portable radios, golf clubs and golf bags. A special prize was presented to the foreign visitor who held the winning number drawn from the complimentary tickets issued to those who were in attendance from foreign operations.

Lane-Wells Granted License to Practice Radioactivity Well Surveying

Lane-Wells Company, pioneers in the field of gun-perforating, has been granted a license under the patents of Well Surveys, Inc., Tulsa, Oklahoma, to practice radioactivity well surveying. This license is exclusive except for two non-exclusive licenses limited to operations on properties operated by the licensees and a license reserved by Well Surveys, Inc., to continue the practice of radioactivity well surveying. Well Surveys, Inc., will manufacture all detecting and recording instruments used by Lane-Wells.

This new method of well surveying permits the logging of formations through casing, thus overcoming the limitations of present electrical logging, which can be performed only in uncased holes.

Lane-Wells is now offering this new logging service in Oklahoma and Kansas and will extend the service to other oil fields as soon as practicable. The results obtained by the new method have clearly demonstrated the effectiveness of this new contribution to the science of finding oil, officials of the company state.

Contrary to erroneous reports published in certain Oklahoma papers, Lane-Wells Company has not taken over either the service or equipment of Well Surveys, Inc., Seismograph Service Corporation, or Engineering Laboratories, Inc. The confusion shown in published reports was probably occasioned by the fact that the owners of Seismograph Service Corporation and Engineering Laboratories, Inc., are also stockholders in Well Surveys, Inc.

Spoiled a Nail but Spared the Pump!

Here's an action picture of how pump mud ends and pump parts are spared the hazards of excess pump pressure. At a point safely below the danger mark the common wire nail has sheared, automatically releasing the pressure. Note how the stainless steel valve stem, through which the nail was set, has raised up as the neoprene piston moved out of the path of the fluid discharge. The only damage is the sheared nail, which is lying on the ground, in two pieces.

This positive, safe and economical means of pump protection has put SHEAR-RELIEF Valves on oil field pumps around the world.

FLUID-PISTON TRIPLEX PUMPS
ABERCROMBIE PUMP CO.
Gulf Building Houston, Texas

SHEAR-RELIEF VALVE

Los Angeles Nomads' Meeting a Social Affair

The regular monthly meeting of the Nomads was held at the California Country Club in Los Angeles, August 14. Except for committee meetings held previous to the dinner, the affair was entirely social. Due to the absence of the president, Ted Sutter, the ceremonies were conducted by Sam Bowen, vice-president of the chapter.

An informal address was given by Charles Hauenstein of the Iraq Petroleum Company who discussed the present conditions and the operating methods in the near eastern countries.

C. H. Curtis, who recently returned from Argentina where he had been doing geological work for the Y.P.F. in Patagonia, spoke on relations with Latin-American countries after describing the work done in the unproved areas south and west of Comodoro Rivadavia. Motion pictures of the country were shown.

Among those present from foreign countries were: John Domeroq, California Arabian Standard Oil Company; H. G. Baker, Bahrein Petroleum Company; H. C. Creath and R. W. Perry of Ultramar Company, Ltd., Argentina; C. K. Banton, British Burmah Petroleum Company; A. V. Sardania, C.N.P., Brazil; James Schaffer, Tex-Col. Petroleum Company, Colombia; M. H. Bush, Bahrein Petroleum Company, and M. J. Bonzerio, Y.P.F., Argentina.

W.P.R.A. Technical Programs At Wichita and Shreveport

The programs for the regional technical meetings arranged by the manufacturing committee of the Western Petroleum Refiners Association under the chairmanship of L. D. Mann, Cities Service Oil Company, have been announced by J. C. Day, secretary of the association. The first of the meetings will be held on October 4 at Wichita, Kansas, the second on October 25 at Shreveport, Louisiana. Three papers will be presented at each meeting, followed by discussion from the floor.

One of the papers at the Wichita meeting will discuss the determining of manufacturing costs of refinery by-products. Although this has always been an extremely important subject, there is very little literature on it. The author of this paper has made a special study of it, and he will present his own ideas as well as the opinions of other authorities.

Catalytic refining in the last several years has come to the front and is one of the foremost methods of refining today. Two papers on the subject will be presented at Wichita, one on catalytic treating of gasoline, and the other a comparison of catalytic and thermal cracking.

Following is the program in detail for the Wichita session:

"Economics and the Relationship of Alternate Products to Refinery Margins," by C. E. Votrian, Bareco Oil Company, Tulsa, Oklahoma.

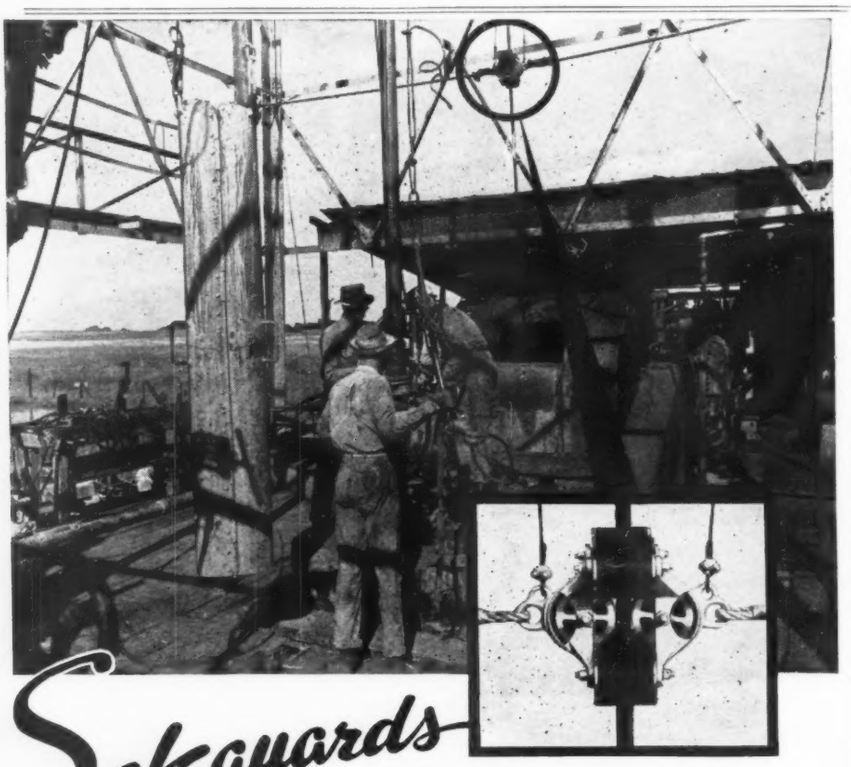
"Comparison of Catalytic and Thermal Cracking," Socony-Vacuum Oil Company in collaboration with E. B. Badger and Sons Company.

"Catalytic Desulphurization," by M. W. Conn, Perco, Inc., Bartlesville, Oklahoma.

The complete program for the Shreveport meeting will be announced soon. It also will cover timely subjects of interest to the refining industry.

Bantam Expands

Nearing completion are the office and factory additions of the Bantam Bearings Corporation, South Bend, Indiana. About one-third more floor space will be added to present factory area to accommodate the new equipment and facilities.



Safeguards LIFE AND PROPERTY

One of the most valuable devices in any rig, this Grizzly Line Saver. It not only pays for itself many times in reduced line wear and breakage, it prevents serious accidents and protects derrick workers against eye injuries from thousands of tiny **wickers** worn off the wire lines. Also eliminates line **whip** without straightening or injuring the line; forces the line to track perfectly and prevents piling up. Wears for years and requires no lubrication or other attention. No operating rig should be without this positive, economical insurance against accidents and excessive line wear.

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GRIZZLY "NO-WIP" LINE SAVER

Lucey Boiler Has New West Coast Distributor

George A. Nelson, (left), Lucey Boiler and Manufacturing Corporation, and Bill Brooks (right), Petroleum Equipment Company, Los Angeles.

Lucey Boiler and Manufacturing Corporation has announced the appointment of Petroleum Equipment Company as its distributors in California. The deal was consummated by George A. Nelson, Lucey factory representative, and Bill Brooks of Petroleum Equipment Company.

Brooks, formerly district purchasing agent for Standard Oil Company at Los Angeles, recently joined the Petroleum Equipment Company. Nelson will continue as direct factory sales representative for Lucey, whose boilers he has distributed on the West Coast since 1934. A complete sales and service program will be perfected covering Lucey's activities in that area.

Lucey recently introduced a 150-hp., 350-lb. working pressure boiler with a rivetless fire box 60 in. by 72 in. by 96 in. By using high tensile strength steel the weight of this boiler was held to only 36,000 lb.

Appalachian Meter School Draws Record Attendance

The 1940 Gas Measurement Short Course held at West Virginia University, August 19, 20, and 21 drew a record attendance with 446 gas men from all over the eastern and southern United States registered. This course, jointly conducted by the University and the Public Service Commission of West Virginia, will from now on also be sponsored by the American Gas Association. This sponsorship was announced by Walter C. Beckjord, president of the association, who was one of the speakers. Other speakers at the general sessions included Dr. C. E. Lawall, president of the University; C. R. Bellamy, Columbia Engineering Corporation; Dr. Paul Price, West Virginia Geological Survey; A. J. McClellan, Manufacturers Light and Heat Company; C. C. Phillips, Ohio Fuel Gas Company; Thomas R. Weymouth, Columbia Gas and Electric Corporation; John Diehl, American Meter Company, and Ray W. Hitchman, United Fuel Gas Company, who served as chairman of the Meter School Committee.

Meetings for the entire registration were held during the forenoon of each day. Speakers covered the field of measurement and control in a broad sense so as to be applicable and of interest to everyone attending the school. The afternoon sessions were devoted to classroom study of specific equipment and problems relating to gas measurement and regulation. These classes were conducted for the most part by engineers from the various equipment manufacturers. Displays by the participating manufacturing companies were in the University Armory.

A highlight in the 1940 session was

"a lion by the tail"

They Need a SURE Safeguard Against Disaster

The measures needed for protecting coastal wells against hurricanes and other contingencies are fast assuming major importance in the industry. Many far-sighted companies within the last year have provided their wells with the **only sure** safeguard against disaster... the Otis Removable Tubing Safety Valve. Yet, this protection cannot be considered complete unless adjoining wells are rendered safe from running wild through the tubing due to failure or damage of surface controls.

When used with the new Otis Pressure Lock Casing Packer, the Otis Removable Tubing Safety Valve provides **complete** protection, so that regardless of what damage may be done to surface connections, the well is instantly, automatically and completely closed in. The simple Safety Valve with its housing is threaded to the lower end of a patented locking mandrel assembly which is identical with that used on the Otis Removable Bottom Hole Choke and Otis Removable Bottom Hole Regulator. With the Safety Valve installed, your well can flow up to a predetermined rate. Flow in excess of that rate, causing even a slight pressure drop through the annular space, automatically causes the Safety Valve to be lifted to its seat in the lower end of the locking mandrel, completely sealing the tubing.

Equalizing pressures across the Safety Valve causes the valve to drop to its open position, allowing flow to be resumed. The Otis Removable Tubing Safety Valve is run under pressure on a steel measuring line and locked at any desired depth in the tubing. It is readily pulled on a steel line without disturbing the tubing string.

OTIS
Pressure Control, Inc.
DALLAS, TEXAS

OTIS "Don't Kill Your Well" Call OTIS

Division Offices: Houston, Tex.; Oklahoma City, Okla.; Hobbs, N. M.
Export Office: 74 Trinity Place, New York, New York, U. S. A.
Representatives: Otis Eastern Service, Inc., Wellsville, New York
Western Pressure Control, Inc., Los Angeles, Calif.

the annual banquet and entertainment at which over 500 registrants and guests were seated. J. K. Buchanan of the Monongahela West Penn Public Service Company, presided as toastmaster and called upon the following speakers: Dr. Lawall, representing the University; Mr. Beckjord, representing the American Gas Association; H. J. Wagner of the Public Service Commission, representing the State, and Colonel W. F. Rockwell, president of the Pittsburgh Equitable Meter Company, representing the equipment manufacturers.

Cardwell Announces Promotions

The Cardwell Manufacturing Company, Inc., Wichita, Kansas, has announced the appointment of Arthur Harvey as general manager of the company. Harvey has been associated with the oil industry for many years and for the last 5 years has served as sales manager for the Cardwell company. After graduation from the engineering school of the University of Kansas, he was employed as construction and maintenance engineer on various railroads, then served with the American Hoist and Derrick Company as sales representative.

R. M. (Bob) Smith, former Illinois sales representative for Cardwell, succeeds Harvey as sales manager. Smith received his education in engineering at Washington University and was a draftsman for the McQuay-Norris Company and sales manager for the W. B. McKnight Machinery Company. Prior to this connection with the Cardwell company, Smith was associated with various independent oil companies as field superintendent, superintendent of production, vice-president, and production manager.

ARTHUR HARVEY

R. M. SMITH

E. R. Jukes has been appointed Illinois sales representative and will have his headquarters at Salem. Jukes is well known in the Illinois basin area and has had extensive experience in drilling and production practices.

STREAMLINED For Light Rotary Drilling

Here's a McKissick Traveling Block that was designed to satisfy a demand for a more compact block that could be used with or without a close-coupled hook. It is unusually rugged in construction and available with two, three, or four sheaves—up to 26 inches in diameter.

Illustration shows block with hook—it is also furnished with clevis adaptable for all hooks.

Illustrated Folder On Request

McKISSICK PRODUCTS CORP.

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TULSA, OKLAHOMA

J. F. Tucker of National Supply Passes Away

JOHN F. TUCKER

John F. Tucker, former general district manager of the Texas Division of The National Supply Company, died Friday, September 6 in Dallas, Texas. Tucker had gone to Dallas from Fort Worth Friday morning on business and died of heart attack after being stricken about 1:15 p.m. while having lunch.

Tucker who was 59, was born in Parkersburg, West Virginia. He worked in the Spindletop oil field for the Guffey Petroleum Company, returning to the East in 1905 for a brief period. In 1908 he entered the employment of the Unity Oil Company but resigned the same year to become associated with The National Supply Company at its Humble office. He was soon put in charge of the branch there and in 1917 was transferred to Houston. In 1923 he was made general district manager and moved to Fort Worth in 1928. Recently he had been in charge of tax work.

M. A. ap Rhys Pryce Killed in Action

Recently it was officially announced by the British Government that M. A. ap Rhys Pryce, well-known petroleum engineer, was killed in action in France in June while serving as a pilot officer in the R.A.F.

Prior to the outbreak of the war, Rhys Pryce was engaged in consulting work in London as head of Drilling and Petroleum Engineering Operations, Ltd. Previous to 1937, when he established this company, he and T. W. Dagg had operated a partnership as petroleum engineers in Trinidad. Later he was variously assistant to the general manager and assistant general manager of Trinidad Leaseholds, Ltd.

Martin O'Donnell of Oil Well Supply Passes Away

Martin O'Donnell, 48, manager of purchases and merchandise of Oil Well Supply Company, died at Dallas, Texas, August 20, following an operation. He was born in Ireland and after graduating from college served in the British army during the World War. He later taught school in England, and in 1920 came to America, where he joined the Wilson-Snyder Manufacturing Corporation. This brought him into the "Oilwell" organization when Wilson-Snyder became a subsidiary of Oil Well Supply Company in 1929.

MARTIN O'DONNELL

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THE PETROLEUM ENGINEER,
Box 1589, Dallas, Texas.

(Enter) (Renew) my subscription for one year. My check in the amount of $2.00 is enclosed.

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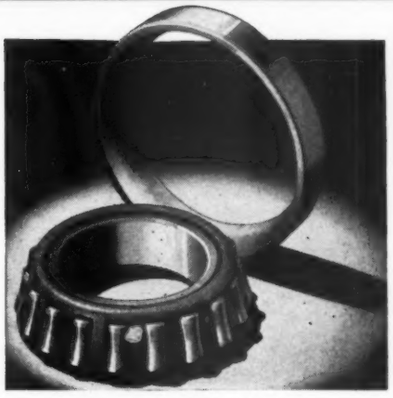

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Pittsburgh Equitable-Merco Nordstrom Install Field Service Trucks in Mid-Continent and Midwest

Wayne Renfro, service engineer, with field truck

As a service and convenience to their customers in the Mid-Continent and Midwest, the Pittsburgh Equitable Meter Company and subsidiary, the Merco Nordstrom Valve Company, now have in operation, from their Tulsa and Chicago offices, completely equipped field service trucks.

These trucks are fitted with the necessary tools, lubricants and test apparatus to handle properly the field maintenance of Emco and Nordstrom products. The Tulsa truck is in charge of Wayne Renfro, service engineer, who is thoroughly trained in factory methods and maintenance procedure on all the companies' products.

Captain A. E. Higgins, sales manager, has announced that similar units will be placed in service in the near future in other areas.

Lane-Wells Headquarters At New Iberia, Louisiana

Lane-Wells new electrolog unit at the recently completed office and shop building at New Iberia, Louisiana. C. J. McWhorter, left, and W. M. Farnsworth, right, Lane-Wells electrolog engineers stationed at New Iberia

To meet a steadily increasing demand for gun-perforating and electrolog services in the Gulf area, Lane-Wells Company recently completed a new office building and shop at New Iberia, Louisiana.

A new electrolog unit, consisting of instrument car and service truck, has been completed and assigned to the district. A second electrolog unit will be delivered in the near future. The New Iberia district, under the management of K. K. Gage, district superintendent, has developed steadily since it was established.

The Lane-Wells personnel at New Iberia includes R. F. Bryant, C. W. Herron, L. E. Manes, and G. C. Robinson, gun-perforator operators; W. M. Farnsworth and C. J. McWhorter, electrolog operators; C. W. Armatta, M. A. Hebert, W. E. McKee, and W. R. Smith at the shops.

John R. Riley Moved to New Orleans by American Iron

John R. Riley, who for the last 14 years has been associated with American Iron and Machine Works Company in various capacities in Oklahoma, Kansas, North Texas, and Illinois, has been transferred to New Orleans, Louisiana, to direct activities of his company in Louisiana, Arkansas, East Texas, and Mississippi. In his new position he will be in charge of the Harvey and New Iberia machine shops and supervise all sales in the abovementioned territories.

Riley has been making his headquarters in Oklahoma City for the last ten years. He has an extensive background and acquaintance in equipment and production circles, having spent several years with the Oil Well Supply Company and as purchasing agent for the Watchorn Oil and Gas Company before becoming associated with the American Iron and Machine Works Company in 1926.

Bill Davis Joins Darling Valve

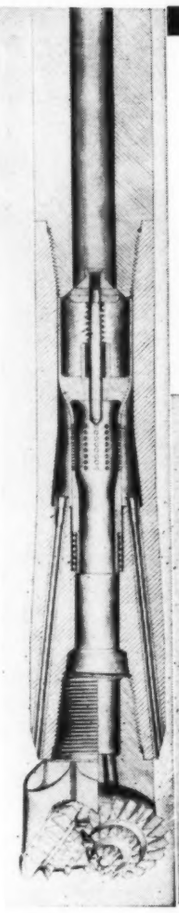
BILL DAVIS

Bill Davis, who for the last three years has been with American Liberty Pipe Line Company, Dallas, Texas, joined the sales staff of the Darling Valve and Manufacturing Company, Williamsport, Pennsylvania, effective September 16.

Davis received a degree in mechanical engineering from Texas Technological College, Lubbock, Texas, in 1937. In addition to American Liberty he has been affiliated at various times with E. F. Moran Drilling Company and Continental Oil Company.

Moves Minneapolis Office

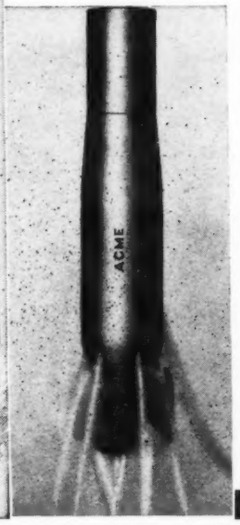
Chain Belt Company, Milwaukee, Wisconsin, announces the removal of its Minneapolis office from 808 LaSalle Avenue to 1645 Hennepin Avenue. R. X. Raymond is Minneapolis district manager.



Have You Seen This Modern-Marvel Tool For Rotary Drilling?

ACME'S MUD COLLAR

(Patents Allowed)



A SENSATION at the Oil Show! Spotlighted by the Oil Industry press! Praised by leading drillers! Already in successful operation in the field! Acme's Mud-Collar is 1940's PROVEN Wonder Tool for rotary drilling!

Its hi-velocity fluid jets, evenly spaced, strike bottom within the hole gage. Breaking up and hydration of bit cuttings mean "*no more balling up.*" Speeds drilling—with less power and strain on equipment. "Breaking circulation" on fishing jobs made easy.

The Mud-Collar's enthusiastic acceptance far exceeds early estimates. When ALL Rotary Drillers KNOW what it will do *for them*—the hazards it overcomes—the time and profits it saves—we won't be able to meet demand!

Order NOW through your Supply Store. Or write TODAY for complete information.

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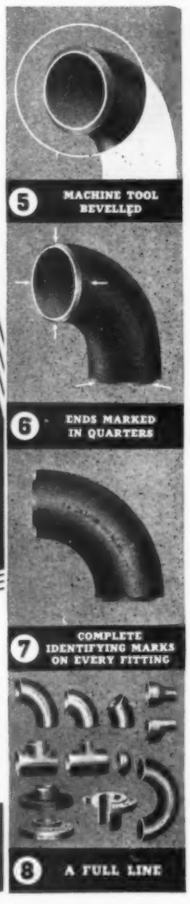
If it hasn't these 8 features it isn't a **WeldELL**



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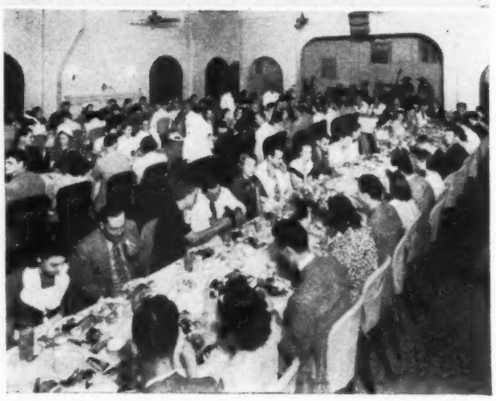
Celebrates Sixth Anniversary

Above: Office building and plant of Well Equipment Manufacturing Company after completion of expansion program



Right: Banquet given at Golfcrest Country Club by C. K. Stillwagon, president of the company

Well Equipment Manufacturing Company, in observance of its sixth anniversary, recently celebrated with a banquet and dance at Golfcrest Country Club, Houston, Texas, C. K. Stillwagon, president, being the host. The annual sales conference of the company was also held in conjunction with the anniversary, with representatives from districts throughout the country in attendance.

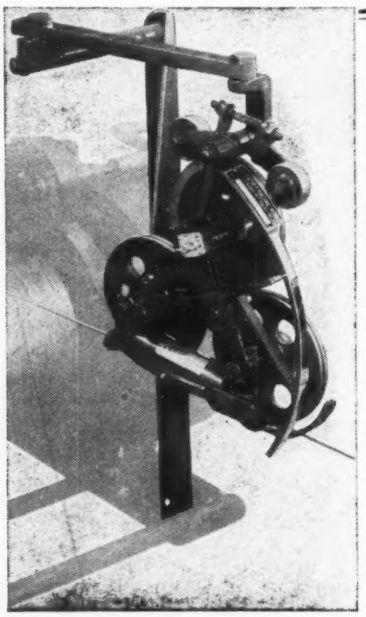
Coincidental with the company's sixth anniversary a sizable expansion program in the office building and plant was completed, giving the organization more than 11,000 sq. ft. of floor space.

Jerry Faubion, Louisiana Representative, McEvoy Company

The McEvoy Company, Houston, Texas, has announced the appointment of Jerry T. Faubion as sales and service representative in the New Iberia, Louisiana, area.

A graduate of Texas A. & M. College, Faubion is well qualified both in training and experience for his position. He was previously associated with the United Gas Public Service Company and Sinclair Refining Company.

Faubion's address is 229 West Main Street, New Iberia, Louisiana. His phone number is 1644.



MATHEY Measure Meter and Weight Indicator

MEASURE METER and WEIGHT INDICATOR

The Type B Measure Meter and Weight Indicator is adaptable to all units using measure meters. It is built for any size measuring or torpedo line.

For any depth work, with reel capacities from 5,000 feet to 15,000 feet of .072 line. Seven models are available for mounting in trailers, cars, pulling-units, and core drills. Self-powered by gasoline engine or power take-off models.

MATHEY PORTABLE MEASURING UNITS

This new measuring device eliminates the factor of human error in well measuring operations, by indicating, on easily read dials, the weight and length of line in the hole.

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Carries the UNDERWRITERS' LABORATORIES Recommendation for use in Class 1 Group D Hazards. See this new lantern at once—New Low Price. At Oil Well Supply Stores.

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To Observe 45th Anniversary of Texas Oil

E. L. SMITH

The forty-fifth anniversary of the discovery of commercial oil production in Texas will be observed this year by the Texas Mid-Continent Oil and Gas Association at its annual meeting in Fort Worth, October 31 through November 2, President E. L. Smith has announced.

It was at Corsicana in October, 1895, that the first commercial oil well in Texas was completed for an initial production of 2½ bbl. per day. Corsicana was the first oil field developed with rotary equipment, and the first rotary rig built will be on display at the convention. Other pieces of equipment used in the early days at Corsicana and other famous Texas fields will be included in the convention exhibit, which will have as background a number of original paintings

GEORGE C. GIBBONS

and etchings of scenes in Texas oil history.

Pioneers in the development of Corsicana and other Texas fields will take part in the convention, where a bronze plaque commemorating the discovery of oil at Corsicana will be presented to representatives of that early oil town. The plaque will be mounted on a miniature derrick or other base, and erected at Corsicana.

Speakers for the convention are now being arranged by George C. Gibbons, executive vice-president of the association. They will include leaders not only in the oil industry but also in general business and government.

The association's 1939 convention, held at Houston, was attended by nearly 1000 oilmen.

E. N. Kemler Resigns From Gulf; Succeeded by D. O. Barrett

Dr. E. N. Kemler, chief production engineer for Gulf Oil Corporation (Gypsy Division), Tulsa, Oklahoma, resigned recently to accept an associate professorship in the Mechanical Engineering Department of Purdue University. He is being succeeded in Gulf by D. O. Barrett.

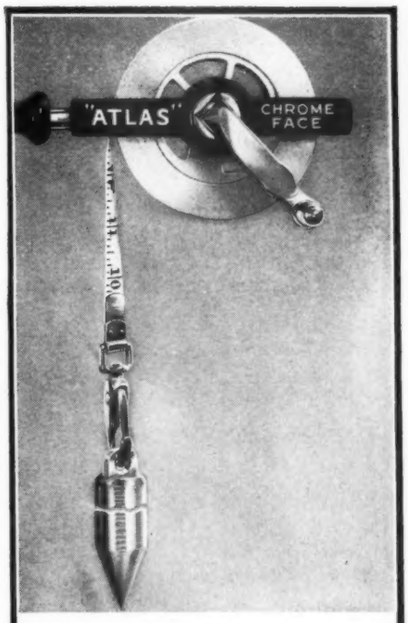
Kemler has been active in the petroleum industry for many years. Prior to assuming his duties in Tulsa he was engaged in research work at Mellon Institute, Pittsburgh, Pennsylvania, and also taught at the University of Pittsburgh. He has also contributed widely to petroleum engineering literature.

Barrett has been with Gulf for the last 11 years, having been division engineer and later assistant superintendent in the Kansas division. Previous to that he was chief engineer for The Superior Gas Engine Company, Springfield, Ohio, for about 10 years.

Bethlehem Supply Opens Two New Texas Stores

Bethlehem Supply Company, Tulsa, Oklahoma, recently opened two new stores in Texas, at LeWard and Seminole. At LeWard J. M. Woods is store manager; J. L. Morgan, assistant store manager; J. P. Branch, field salesman, and John A. Rich, floorman. This store is under the supervision of R. A. Brown, district manager, who has his headquarters at Corpus Christi, Texas.

J. W. Stewart is store manager at Seminole; Virgil Moon, assistant store manager, and W. M. Vandivert, field salesman. The store is under the supervision of R. E. Throckmorton, district manager, whose headquarters are Midland, Texas.



LUFKIN

"ATLAS" CHROME FACE OIL GAGING STEEL TAPE

No one is more in need of an easy to read, durable, accurate steel tape than the oil man. And no tape answers those requirements better than the new "Atlas" Chrome Face. Its jet black markings are easy to read even in poor or artificial light. The satin chrome surface throws them up in high relief — won't rust, crack, chip or peel. It's remarkably free of glare and is easy to clean. You'll see its superiority by looking at it — but you have to use it to fully appreciate all its advantages.

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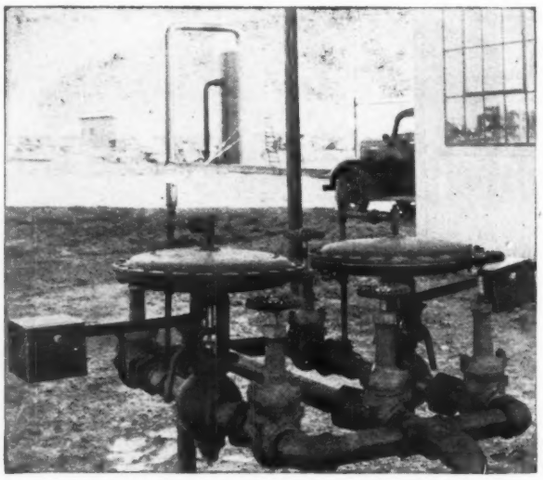

THE two C-F Low-Pressure Regulators with Automatic Cut-Off here seen, are on a gas line of a Texas refinery owned by one of the great oil-producing companies. Like all C-F low-pressure Regulators, they afford protection in case of failure of gas supply. Their merits include sturdy construction, sure precision, and long life as well as easy installation and maintenance. Write for new Catalog.

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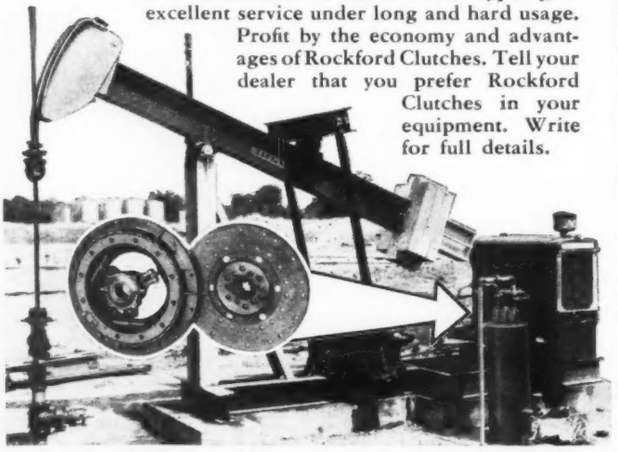
Specify Rockford Clutches

... Insure Reliable Control of Engine Power

THE power unit in the pumping operation illustrated below has a Rockford Over-Center Clutch for dependable power transmission control. Rockford Industrial Clutches also perform with complete satisfaction and economy in tractors, drilling drives, generator units and many other applications. The Over-Center Clutch locks in and out of engagement. The Rockford Spring-Loaded Clutch works like an automobile clutch. Both types give excellent service under long and hard usage. Profit by the economy and advantages of Rockford Clutches. Tell your dealer that you prefer Rockford Clutches in your equipment. Write for full details.



Rockford Drilling Machine Division Borg-Warner Corporation

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Over-Center, Spring-Loaded and Pullmore Clutches

Book Reviews

Handbook of Mathematical Tables and Formulas compiled by Richard Stevens Burington. Published by Handbook Publishers, Inc., Sandusky, Ohio. Second edition, 1940. 282 pp., 58 figs., 5¼ x 7¾, single copy price, postpaid, $1.25.

This valuable reference book, also published as the appendix of Lange's Handbook of Chemistry by the same publishers, has now been made available in separate form.

Its 38 subdivisions present many types of basic data that are not readily available elsewhere under a single cover.

* * *

Petroleum Development and Technology, 1940. Published by American Institute of Mining and Metallurgical Engineers, 29 West 39th Street, New York, New York. 597 pages. Price $5.00 net; bound in cloth.

Anticipated each year by many non-members of the A.I.M.E. as an authoritative source of valuable basic data concerning oil and gas operations of the world, this new volume is the fifteenth annual treatise of its kind.

Its five chapters are devoted to (I) Production Engineering, (II) Engineering Research, (III) Petroleum Economics, (IV) Production, Domestic and Foreign, and (V) Refining.

* * *

Twelfth Report of the Committee on Catalysis. Compiled under auspices of the National Research Council, National Academy of Sciences. Published by John Wiley and Sons, Ltd., New York. 338 pages. Price, $5.00.

This report presents a somewhat critical and proportioned impression of the state of progress of catalysis, with a resumé of some of the important work published since the appearance of the eleventh National Research Council report. In the execution of this plan, certain trends have been recognized. As the pertinent literature on catalysis is now too great to be evaluated by any one man, the various members of the committee agreed to coöperate in the writing of a single report. The committee members have been chosen with this plan in view and on the basis of their participation in major fields of the increasingly complex subject of catalysis. The committee is reorganized after each report in order that the most suitable personnel should deal with the succeeding report, the topics of which necessarily change somewhat. The report is not encyclopedic, and some topics, such as catalysis in solution, have been reserved for future undertakings.

* * *

Oil and Gas Field Development in United States, 1939. Edited under direction of Hervey L. Eversburg. Published by National Oil Scouts and Landmen's Association, Austin, Texas. 608 pages. Available only to members of association.

This issue of the National Oil Scouts and Landmen's Association Yearbook is the first to present a complete review of development in all oil and gas producing states of the United States; information on prospective oil states is also included. Beginning in 1930 with a slender volume of 327 pages whose scope was confined to the southern part of the Mid-Continent, the contents of each succeeding annual have been augmented. Each year the area covered has been enriched and with this issue the objective of the organization has been practically attained, a statistical review of the development branch of the petroleum industry in the United States.

Graver Tank and Manufacturing Company Adds General Construction Division

LLOYD K. WELLS

Graver Tank and Manufacturing Company, Inc., East Chicago, Indiana, has formed a division for the purpose of constructing equipment and other facilities for the petroleum industry. In discussing this new service, E. N. Gosselin, president of the company, stated: "Due to the increasing trend of oil companies to avoid fluctuating forces as much as possible, they are placing their construction work with experienced contractors qualified to obtain the best results, and Graver believes that its construction division can, and will, be of definite value to the petroleum industry as a whole.

"The activities of this new division, organized as a separate erecting department, will be confined to construction work only and will work from plans and specifications supplied by the customer, but will do no engineering or designing. This policy, we believe, will tend to effect greater economies in the construction of petroleum equipment and other facilities, and will enable the oil companies to relieve themselves of all worry and trouble attendant with handling construction projects."

Lloyd K. Wells, prominent construction engineer, for many years identified with erection of all kinds of refinery equipment and other facilities, is manager of this division. From 1922 to 1940, Wells held responsible positions as construction engineer, foreman, superintendent, and general construction superintendent in the erection of all types of equipment and construction, and is well known in the petroleum industry.

Miller Sand Pump Company Opens Salem, Illinois, Branch

S. John Smith, general manager of the Miller Sand Pump Company, announces the opening by the company of a service branch and warehouse at Salem, Illinois, on Route 50, P. O. Box 152, Telephone 101.

In addition to carrying complete stocks of Miller sand pumps and boilers, assuring immediate delivery to the Illinois fields, a large rental stock of cable-tool drilling and fishing tools will be stocked.

C. C. "Stormy" Guinn will be in charge of this store with J. Ed. Ragan, Miller field representative.

General office and plant of the Miller Sand Pump Company is at 1524 S. E. 29th Street, Oklahoma City, Oklahoma. Other Miller service branches and warehouses are maintained at Sapulpa, Oklahoma, and Kilgore, Texas. In addition to complete stocks of Miller sand pumps and boilers at Oklahoma City, Sapulpa, and Kilgore, a diversified line of oil-field supplies is carried and complete well-equipped machine shops are maintained at these three points. Export offices in charge of Val R. Wittich, Jr., are maintained at suite 4616, 30 Rockefeller Plaza, New York City.

Other Miller products are Jiffy Pipe Clamps, Hardman Rod Line Oil Savers, and Hardman Casinghead Pumping Assemblies.

THE BEST VALVE IS NATURALLY *Self-Cleaning*

A valve must remain in operation, free of foreign matter. The best valve, therefore, *cleans itself* throughout its entire stroke, and has no internal guides to cause foul-up.

The best valve also assures smooth, positive operation by unwedging and freeing gates *before* raising, wedging them only when they are directly opposite ports. It allows ready replacement of parts through ample tolerances; it guarantees positive closure with self-releasing 30° angle wedges, and gates *self-adjusting* to seats. It permits no pressure shock.

Only the parallel seat, double wedge type slide gate valve provides *all* these essential benefits. This principle, developed and perfected by Ludlow, has been universally accepted and preferred for oil, gas and water lines since 1866.

Information free on request.

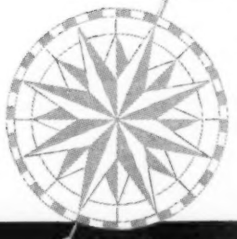
The LUDLOW VALVE MFG·CO·INC· SINCE 1866 TROY·N·Y·

Natural Gas Carburetion BY ENSIGN

A few moments each year we like to raise up from our work, take a fresh breath and check our position by the compass. The best compass we know of is the reaction of our old and valued customers.

An interesting observation made at the 1940 Tulsa Oil Show, in May, revealed a total of 153 engines equipped for Natural Gas Carburetion. Of this number 138 were Ensign equipped leaving 15 installations for all other makes. This ratio has consistently been in favor of Ensign for over eight years, during which time more than 50,000 Ensign Natural Gas installations were made. These figures we believe, are significant.

We are indeed grateful to our many Oil Field and Standard Equipment accounts for their confidence and patronage.



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WE SPECIALIZE IN LIFTING OIL FOR LESS MONEY

We are the oldest and largest manufacturers in the world making pumping equipment only.

Producers from coast to coast have kept us going and growing because they have less trouble and expense when they pump their wells with JENSEN UNITS.

You can safely ask your JENSEN dealer or Wire-Phone-Write us at Coffeyville for facts pertinent to your field and your wells, because we don't want your business unless we can cut your expenses. Only satisfied customers are profitable.

JENSEN BROTHERS MANUFACTURING CO.

"The House that Jacks Built"

Coffeyville, Kansas

EXPORT OFFICE: 50 CHURCH ST., NEW YORK CITY

This RIGID
Guarantee Does Cut
Your Wrench Costs
UNCONDITIONAL GUARANTEE
If this Housing ever Breaks or Distorts we will replace it Free.
THE RIDGE TOOL CO. ELYRIA, O.
TRADE RIGID MARK

THIS amazing RIGID has won world-wide popularity among the most critical pipe wrench users because it really does end all wrench housing repairs and expense. Because the adjusting nut always spins easily to size. Because its safe chrome molybdenum replaceable jaws are instant grip and let-go and the I-beam handle is both powerful and easy on the hand. A tool a man enjoys using—and it saves you money. Buy from your Supply House.

THE RIDGE TOOL CO., ELYRIA, OHIO

RIGID PIPE TOOLS

Dowell Incorporated Announces Promotions

In a move to coöperate more closely with Gulf Coast operators, Stanley C. Morian, formerly district engineer at Houston, Texas, for Dowell Incorporated, has been promoted to sales engineer attached to the general sales staff. Morian will maintain his residence at Houston with business offices in the new Commerce Building. He is the third generation in his family to be associated with the oil industry. Morian took his B.S. degree in petroleum engineering at the University of Oklahoma in 1934, and upon graduation became associated with the Gulf Oil Corporation, in whose employ he held various positions, from field clerk to production engineer at Hobbs, New Mexico. In April, 1937, he joined Dowell in its West Texas operations. Morian for the last two years has been in the Gulf Coast area with the special assignment of studying chemical service problems.

STANLEY C. MORIAN

JACK SUTHERLIN

Jack Sutherlin, until recently a station manager for Dowell Incorporated at Great Bend, Kansas, has been promoted to a research engineering post with headquarters in the Tulsa, Oklahoma, offices of the company. Sutherlin was born in Texas and has been associated with the oil industry since leaving Texas A. and M., where he majored in geology. Upon leaving school, Sutherlin was employed by the Cabot Company in the technical department. In the five years of his association with Dowell Incorporated, Sutherlin has spent most of his time in the Western Kansas oil fields, having left only for periodic training in other areas.

Reagin E. Dublin has been transferred from Hays, Kansas, to Great Bend as station manager. Jack Sampson succeeds Dublin at Hays as station manager. He was promoted from his treating engineer's post at Great Bend.

S. L. Stentz Joins National Tank

S. L. Stentz joined the sales department of the National Tank Company September 1 as sales engineer.

He graduated from the Carnegie Institute of Technology in engineering in 1931.

Before entering sales work he spent seven years in heavy foundation construction and steel mill operation in the Pittsburgh district.

Since 1934 he has represented the A. M. Byers Company of Pittsburgh as district representative in the northern Mid-Continent area.

Establishes Rocky Mountain Division Office

C. S. MEECE

The Eastman Oil Well Survey Corporation officials announce the establishment of a new division office for the Rocky Mountain States at 355 C-Y Avenue, Casper, Wyoming. C. S. Meece has been appointed division manager.

The personnel chosen to extend oil-well surveying and controlled directional drilling services to this division are from the California and Mid-Continent areas, where they have had extensive experience.

Removable and casing whipstocks, knuckle joints, directional bits and reamers, single shot instruments, drift indicators, etc., are now available at Casper.

C. H. Seger, Jr., Made Division Sales Manager for Bethlehem Supply

C. H. SEGER, JR.

G. A. Tompson, vice-president of Bethlehem Supply Company, announces the appointment of C. H. Seger, Jr., as division sales manager, to be situated in Houston, Texas, under the direct supervision of C. C. Crider, southern division manager.

Seger has been a resident of Tulsa, Oklahoma, for a number of years, having graduated from Tulsa Central High School. He received his degree in finance and banking from the University of Illinois. Seger formerly was connected with the National Bank of Tulsa, handling principally oil credits, and is widely known in the oil fraternity. He became associated with Bethlehem in 1938, as credit manager, serving in that capacity until now.

A REAL BARGAIN

Refrigerator and Power Equipment, consisting of ammonia compressor and all auxiliaries, including 90, 75 and 50 horsepower gas engines with three phase A.C. direct connected generators. In use only two years. Attractive price for quick sale. Address Box 22, c/o *The Petroleum Engineer*, 700 Allen Building, Dallas, Texas.

How to Order BALLS *and* SEATS

1. First, specify **"B-M-W"** thereby assuring yourself of the highest quality obtainable.
2. If you want a stainless steel Ball and Seat, perhaps the most widely used in the U. S., and possibly the world, add the trade name "CHROMARD." In other words, it is known among oil men as "B-M-W CHROMARD."
3. If you want the hardest non-corrosive metal, specify "MONARCH."
4. For highest quality alloy steel—"BRAMO."
5. For a very high grade monel alloy—"LUMONEL."
6. For an extremely hard bronze ball and a stainless steel seat—"BI-METAL."
7. And, finally, if you want both Ball and Seat to be the highest grade hard bronze alloy, specify "EXTRARD BRONZE."

One of these will surely handle your pumping problem, whatever the load may be—heavy, medium, or light—and if you are troubled with sand, lodestone, corrosion, magnetic troubles, or ball breakage. We have had exceptional experience in the manufacture and application of a wide range of pumping equipment and will gladly assist you with your problems.

Ask for complete data.
See our ad. in the latest Composite Catalog.

B-M-W BALLS AND SEATS ARE SOLD BY

the best supply stores, together with other B-M-W Products: NU-TEX Working Valves . . . NEILSON Tools (Safety Sucker Rod Hooks, Rod Elevators, Sucker Rod Sockets, Etc.) . . . ADMORE Insert Pump Anchors . . . ADMORE Liner Barrels . . . TEX TYPE Plunger Fittings and Valves . . . COLLINS Belt Clamps . . . FLUID-LIFTER Pumps . . . NU-TEX Pumps . . . the 2-WAY NON-MAGNETIC Crown, and the TOWER TYPE Ball and Seat.

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OIL WELL SUPPLIES
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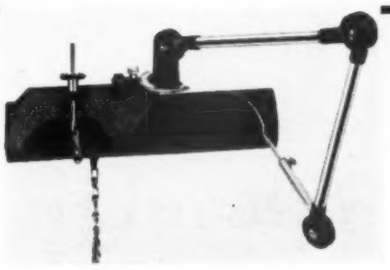
. . . WELDERS!
Save Time and Material



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Every cut is marked right the first time.

The accuracy of Trumark Protractors is certified by Smith-Emery Co., Los Angeles testing engineers.

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NEW LIGHT ON YOUR CLEANING JOBS

EASIER WAY TO CLEAN YOUR INTERCHANGERS

In one Western oil refinery, cleaning interchangers once was really work. Dismantling, cleaning, and re-assembling equipment took a lot of time and effort... not to mention the extra expense.

But now that an Oakite material is on the job, how the picture has changed. At periodic intervals, a hot solution made up with the recommended Oakite material is circulated as directed and then drained. Interchangers are restored to full efficiency. Dismantling is a thing of the past. And cleaning costs are amazingly low!

Want more details on this or such other jobs as safely de-scaling Diesel cooling systems and cleaning "lube" oil coolers? Then write today for helpful, money-saving data on your cleaning problems. No obligation.

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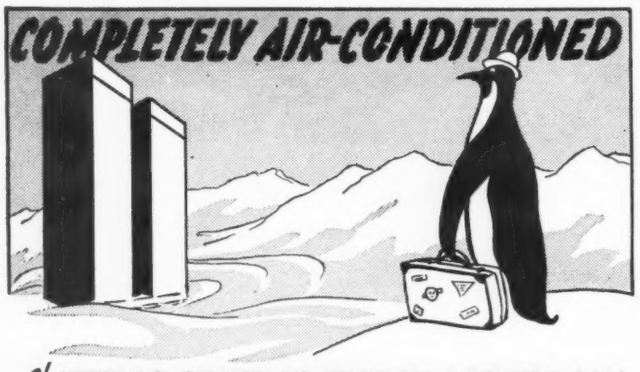
Representatives in all Principal Cities of the U. S. and Canada

OAKITE *certified* CLEANING
MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT



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Through the hot summer months, Houston's TEXAS STATE HOTEL provides a cool, healthful atmosphere for its guests. Individual controls in each room assure you of just the temperature you want—and a restful, refreshing visit.

The TEXAS STATE offers a convenient downtown location, close to offices, shops and entertainment; large, comfortable rooms; the finest meals.

Next time you're in Houston, stop at the TEXAS STATE, and you'll echo the words of the Penguin above.

TEXAS STATE HOTEL
HOUSTON

Trade Literature

"The Welding of Republic Enduro Stainless Steel" is the title of a new 20-page booklet released by Republic Steel Corporation, Cleveland, Ohio. The booklet is profusely illustrated and contains up-to-the-minute data on the welding of stainless steel by various commercial methods, including electric arc, atomic hydrogen, flash, projection, seam, spot, and gas. Brazing and silver soldering are also treated. A feature of the booklet is a section containing a large number of drawings demonstrating the proper design of welded joints for stainless steel construction.

Copies of the new booklet, Form ADV 373, are available upon request to Republic Steel Corporation, Advertising Division, Cleveland, Ohio.

●

Two new higher-capacity vibrating screens for reconditioning rotary mud, are illustrated and described in Folder No. 1872, announced by Link-Belt Company, 307 North Michigan Avenue, Chicago, Illinois. Both sizes (48 in. by 60 in. and 24 in. by 48 in.), are now completely unitized and readily portable, for shallow, medium, and deep-well service. Features, complete specifications and dimensions for both individual and dual hook-up, are contained in this new folder, which may be obtained by writing to the company.

●

Macwhyte Company, Kenosha, Wisconsin, has issued a pamphlet describing how thorough lubrication lengthens the service life of wire rope. This is No. 5 in a series of informative articles for wire rope users prepared by the company, copies of which will be sent free upon request.

●

General Electric Company, Schenectady, New York, has issued bulletin GEA-3377 entitled: "Ways to Save with Load-Center Distribution of Electric Power."

Load-center distribution is the practice of bringing primary electric power close to the load by locating the distribution transformers near the actual point of application of the electric energy. In considering load-center distribution in the past, industrial engineers have been accustomed to thinking in terms of oil-filled transformers situated out-of-doors or housed in fireproof concrete vaults. With the development of Pyranol and the Pyranol transformer, a new flexibility in installation has been made possible, the manufacturer states. This bulletin has been prepared to acquaint the industrial engineer more fully with the possibilities and economies of load-center distribution with Pyranol transformers.

●

Refiners faced with the problem of removing water scale and other deposits from various types of heat exchange equipment, will be interested in a new, illustrated 20-page booklet issued by Oakite Products, Inc., New York City. In outlining safe, modern methods for effectively handling this maintenance work, the booklet describes a recently developed material, Oakite Compound No. 32, which is designed to provide high rust and scale removal properties. Because of its wide range of activity, the material also makes possible the safe, effective, de-scaling of cooling coils, economizers and vacuum condensers, as well as cooling jackets of Diesel and gasoline engines, booster pumps and compressors without the need of expensive, time-consuming mechanical methods, it is stated.

Copies of this booklet may be obtained by writing to Oakite Products, Inc., 48 Thames Street, New York, New York.

MEETINGS

California Natural Gasoline Association, Monthly Meeting—October 3, Richfield Building, Los Angeles, California.

Western Petroleum Refiners Association, Regional Meeting—October 4, Wichita, Kansas.

American Gas Association—October 7, 8, 9, and 10, Atlantic City, New Jersey.

National Safety Congress and Exposition—October 7, 8, 9, 10, and 11, Hotel Stevens, Chicago, Illinois.

Indiana Independent Petroleum Association, Fall Convention—October 9 and 10, Hotel Severin, Indianapolis, Indiana.

National Stripper Well Association—October 15, Dallas, Texas.

Independent Petroleum Association of America, Annual Meeting—October 16, 17, and 18, Dallas, Texas.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 17 and 18, Los Angeles, California.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 24, 25, and 26, Tulsa, Oklahoma.

Western Petroleum Refiners Association, Regional Meeting—October 25, Shreveport, Louisiana.

Texas Mid-Continent Oil and Gas Association—October 31, November 1 and 2, Fort Worth, Texas.

California Natural Gasoline Association—November 1, Los Angeles, California.

American Association of Petroleum Geologists—November 7 and 8, Los Angeles, California.

American Petroleum Institute, 21st Annual Meeting—November 11, 12, 13, 14, and 15, Stevens Hotel, Chicago, Illinois.

American Institute of Chemical Engineers—December 2, 3, 4, 5, and 6, New Orleans, Louisiana.

American Petroleum Institute, Southwestern District Division of Production—February 27 and 28, 1941, Washington-Youree Hotel, Shreveport, Louisiana.

Indiana Independent Petroleum Association, Spring Convention and Refiners' and Suppliers' Exhibit—March 11, 12, and 13, 1941, Hotel Severin, Indianapolis, Indiana.

American Association of Petroleum Geologists—April 2, 3, and 4, 1941, Rice Hotel, Houston, Texas.

Natural Gasoline Association of America, Annual Meeting—April 23, 24, and 25, Baker Hotel, Dallas, Texas.

National Petroleum Association—April 24 and 25, 1941, Semi-annual Meeting, Hotel Cleveland, Cleveland, Ohio.

American Society for Testing Materials—June 23, 24, 25, 26, and 27, 1941, 44th Annual Meeting, Palmer House, Chicago, Illinois.

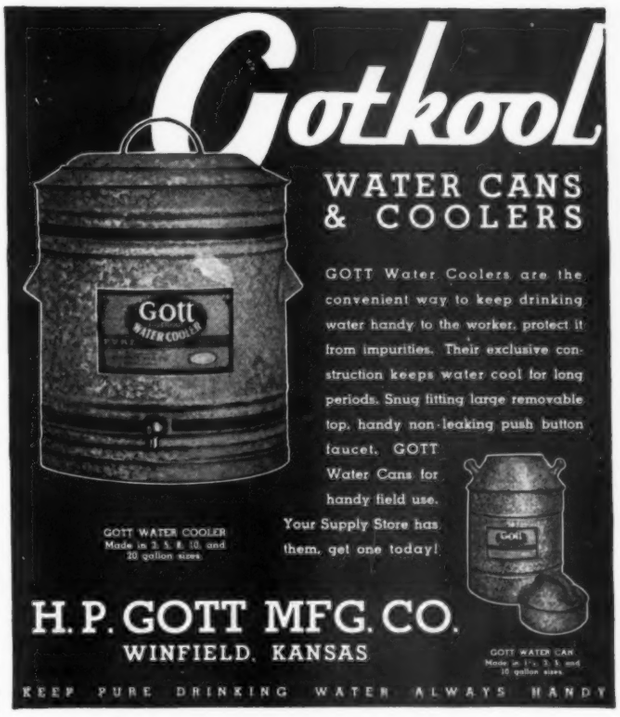
Lane-Wells' July Gross Sets Mark

Lane-Wells Company, Los Angeles, California, reports July gross revenue from sales and royalties of $291,200 for a new monthly peak in the company's history and about 4 percent greater than the previous record of $279,000 for April, 1940.

Continental Supply Opens Two Stores

Announcement has been made of the opening of a new store at LaWard, Texas, by The Continental Supply Company. The manager is F. W. Harlow.

Continental is also reopening its store at Hebbronville, Texas, which will be under the direction of H. A. Bradley.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GOTT Water Coolers are the convenient way to keep drinking water handy to the worker, protect it from impurities. Their exclusive construction keeps water cool for long periods. Snug fitting large removable top, handy non-leaking push button faucet. GOTT Water Cans for handy field use. Your Supply Store has them, get one today!
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Made in 3, 5, 8, 10, and 20 gallon sizes.
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H. P. GOTT MFG. CO.
WINFIELD, KANSAS
KEEP PURE DRINKING WATER ALWAYS HANDY

NORTH! SOUTH! EAST! WEST!
SAND-BANUM
"The Entirely Different Boiler and Engine Treatment"
The same Sand-Banum is keeping scale and corrosion out of boilers and engines for operators in every section of the country.
They have found it most advantageous to adopt Sand-Banum for regular use. That is why we know you, too, will find Sand-Banum of great value.
Let us tell you about this simple, safe and efficient treatment. There is no obligation—write today.
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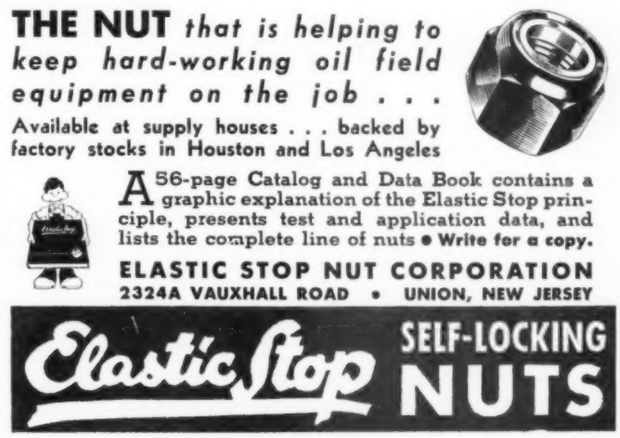
THE NUT that is helping to keep hard-working oil field equipment on the job . . .
Available at supply houses . . . backed by factory stocks in Houston and Los Angeles
A 56-page Catalog and Data Book contains a graphic explanation of the Elastic Stop principle, presents test and application data, and lists the complete line of nuts • Write for a copy.
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Elastic Stop SELF-LOCKING NUTS

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MILLER

Increases Production

The MILLER Sand Pump is always FIRST CHOICE of men who watch production costs closely. That's why it's used throughout the World for cleaning-out quicker...

INCREASING PRODUCTION

The MILLER is made in diameters of 2½, 3, 3½, 4, 4¼, 5, 5½, 7 and 9 inches and lengths of 20, 25 and 30 feet. 5/32-inch wall thickness in REGULAR Type, ¼-inch wall tubes HEAVY DUTY Sand Pumps.

INTERCHANGEABLE BOTTOMS

To Meet Every Condition

● BAILER BOTTOM

With the Bailer Bottom installed the MILLER is quickly changed to a Bailer giving you a combination of either Bailer or a Sand Pump in one tool.

● SAND BOTTOM

Used when tools are run and when well is shot to quickly remove loose material.

● STAR BOTTOM

Used for cutting the sand loose.

● CHISEL BOTTOM

(In Pump)

With this bottom tightly packed sand can be easily broken in small pieces so it can be picked up in the pump.

Write for Descriptive Folder and Price List

See Pages 1672-73 COMPOSITE CATALOG

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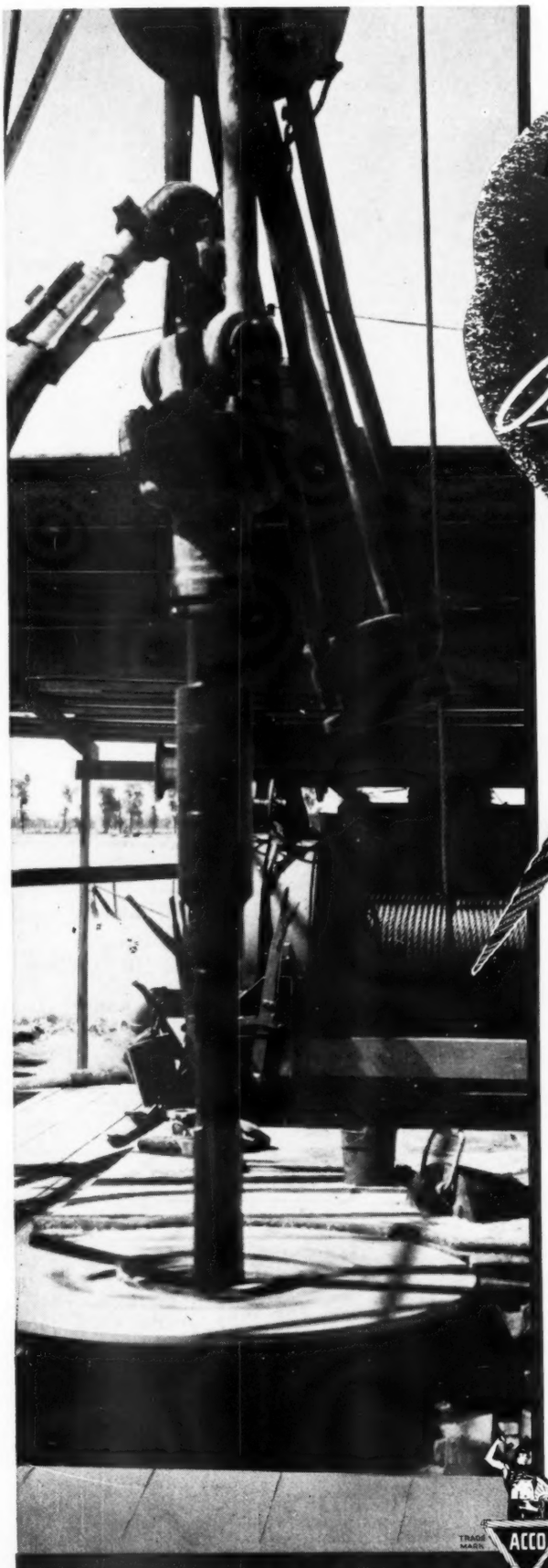

American Cable TRU-LAY Preformed Rotary Lines don't object to work. Indeed, from its complete freedom from kinkiness, crankiness, orneriness, TRU-LAY Preformed seems to want to work. When you string your rig with TRU-LAY Preformed you'll find it doesn't fight the men who work with it; it doesn't snarl and jump into unruly tantrums. . . . Because TRU-LAY is preformed—flexible, relaxed. Then, once in place, you'll find TRU-LAY Preformed whips less, spools better, makes possible faster round trips. In rotary drilling insist on American Cable TRU-LAY Preformed Emerald Strand—the line that's *safer* for both men and production economy.

In cable tool work specify American Cable CRESCENT Non-preformed. There is the line with the reach—the line that possesses the same built-in quality of other ACCO Products whether for American Cable Wire Lines—American Welded and Weldless Chains—Ford Chain Blocks—Page Welding Wire—Reading-Pratt & Cady Valves—or any of the other 137 ACCO Quality Products.

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In Business for Your Safety
Branches or Distributors in All Oil Field Centers

Green Signifies Full Speed Ahead for National Preparedness

TRADE MARK ACCO

AMERICAN CHAIN & CABLE COMPANY, Inc.

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FROM THE CEMENT PLANT TO THE BOTTOM OF YOUR WELL... *that's "Bulk Cementing"*

LATEST HALLIBURTON INNOVATION

Eliminates waste, breakage and spoilage due to messy handling of cement in sacks at a well . . .

Provides *faster, more uniform* mixing . . .

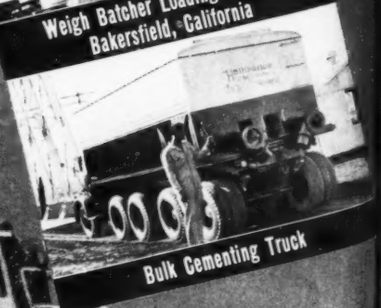
Yet it costs no more!

Now available in Illinois and California. Constructive program under way to make it available in other areas.

HALLIBURTON OIL WELL CEMENTING CO.

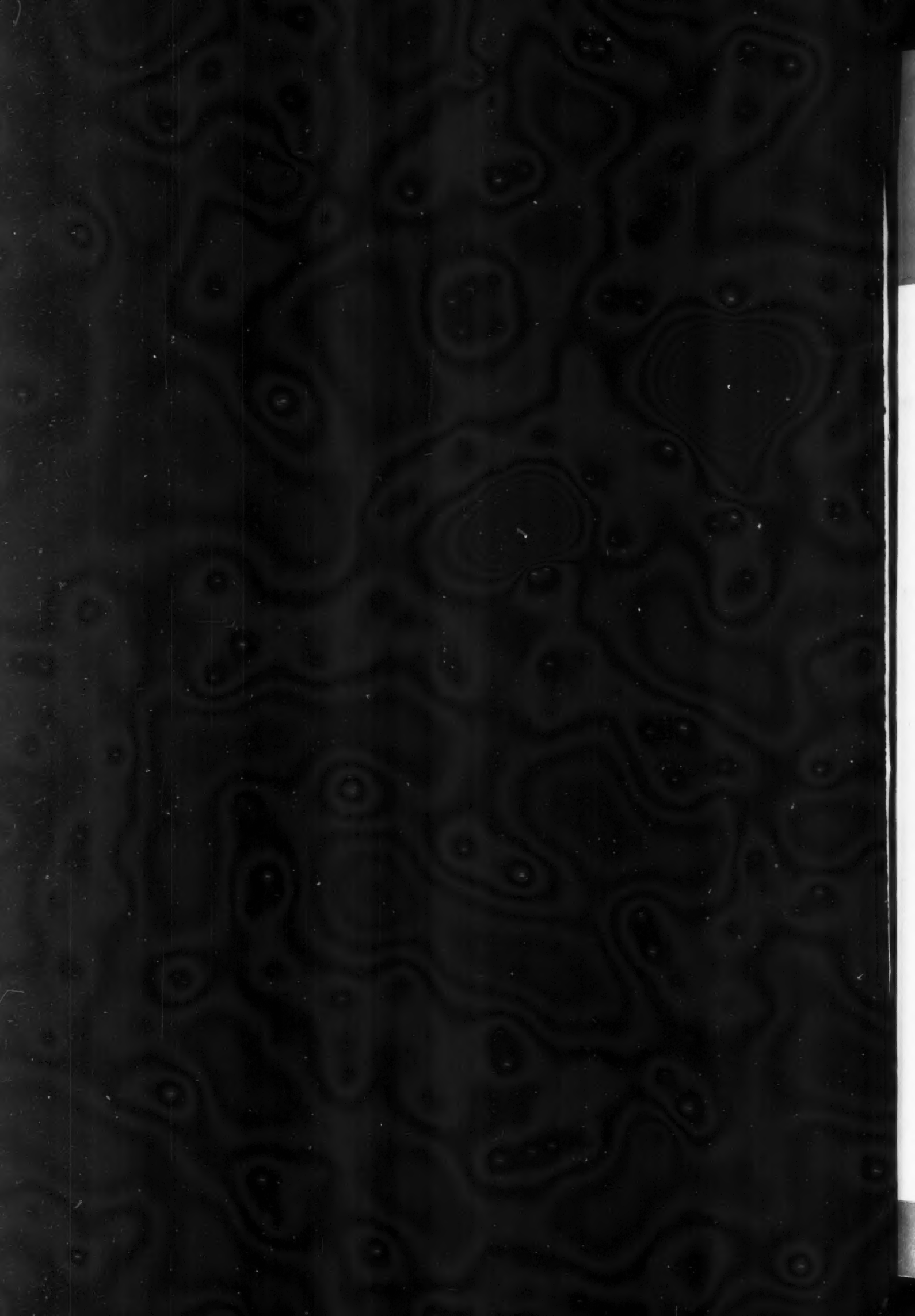
Bulk Cementing Plant, Salem, Illinois

Weigh Batcher Loading Truck at Bakersfield, California



Bulk Cementing Truck

BULK PLANT AT BAKERSFIELD, CALIFORNIA



THE Petroleum Engineer
DALLAS, TEXAS

The invariable dependability of Tretolite is the most important factor in the continued success of Tretolite. This dependability is due to other qualities—accuracy, efficiency, and economy. The combination of these factors insures complete satisfaction whenever Tretolite is used in the treatment of crude oil to pipe line requirements.

TRETOLITE COMPANY

Manufacturing Chemists

DALLAS **ST. LOUIS** LOS ANGELES

Representatives in All Principal Fields

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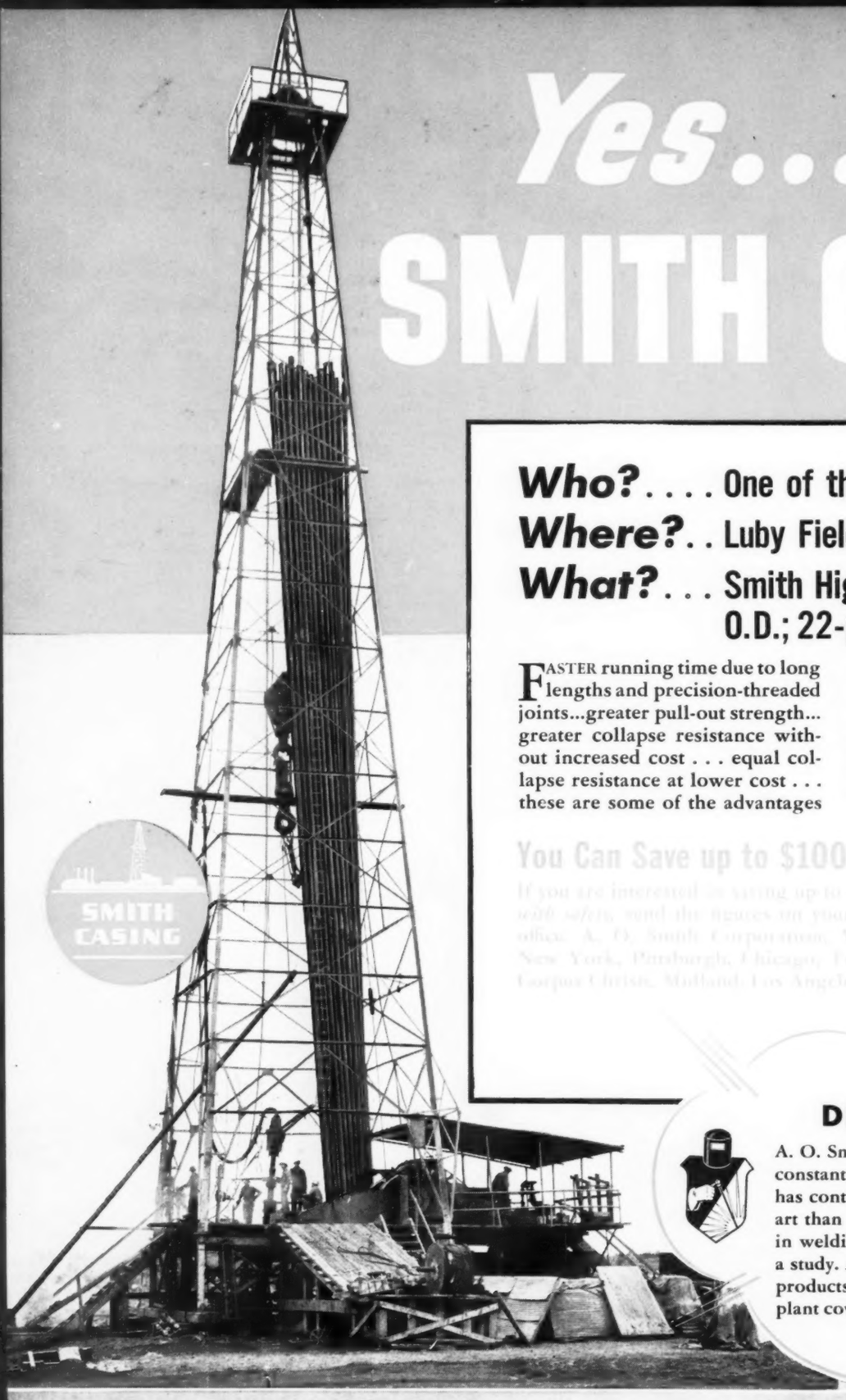

Yes...It's SMITH Casing

Who?.... One of the Major Companies
Where?.. Luby Field, Texas
What?... Smith High Yield Casing; 7-inch O.D.; 22-pound; 50-foot Lengths

FASTER running time due to long lengths and precision-threaded joints...greater pull-out strength... greater collapse resistance without increased cost . . . equal collapse resistance at lower cost . . . these are some of the advantages that many operators are realizing through the use of Smith Casing. There is additional satisfaction in the knowledge that *each length of Smith Casing is automatically tested* in the making. Calculated and actual safety factor are identical.

You Can Save up to $1000 or More on Each Well

If you are interested in saving up to $1000 or even more on each well *with safety*, send the agencies on your next string to the nearest Smith office. A. O. Smith Corporation, Milwaukee, Wisconsin. Offices at New York, Pittsburgh, Chicago, Tulsa, Dallas, Shreveport, Houston, Corpus Christi, Midland, Los Angeles.

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A. O. Smith pioneered welding, and through constant research and diversified experience has contributed more to the perfection of the art than any other concern. Smith leadership in welding is recognized by all who make it a study. An average of 25,000 tons of welded products leave the Smith plant monthly. The plant covers 125 acres, 53 of them under roof.

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CORPORATION
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Casing
Pressure Vessels • Line Pipe

A 'Snap' TO DO WORKOVERS

GROVER SEIBELMAN

J. F. CORLEY

PRODUCTION SERVICE CO.
Reeling, Swabbing, Tubing Pulling, Workovers
5102 OLD SPANISH TRAIL
P. O. BOX 1809
J. 29374 OR H. 7464
HOUSTON, TEXAS

May 21, 1940

Cardwell Manufacturing Company, Inc
P. O. Drawer #2001
Wichita, Kansas

Gentlemen:

Referring to your letter of May 14, asking for operating information on the "Cardwell" Model S workover draw works recently purchased from you, this information is as follows:

The Model S is operating in the Dickinson field, Galveston County, Texas, cutting screen and liner at 8000', using 2-1/2" tubing The operation has been unbelievably smooth

On this job we are making round-trips from 8000' in six hours, handling trebles of ten-thread tubing, making up and breaking out by hand. We believe that this time cannot be greatly improved upon by a steam rig.

This Model S has created quite a bit of interest among the operators in South Texas because of its ease of operation and the cushioning performance of the fluid transmission with its air controlled friction clutched "Hi-Lo" drive, resulting in increased speed over our other "Cardwell" rigs.

Our operators are particularly pleased in having the air operated water pump for cooling the brakes and washing the floor.

We are attaching photographs of this rig in action.

Very truly yours,

PRODUCTION SERVICE COMPANY

J. Corley
J. F. Corley
Partner

EVERY operation with this up-to-the-minute, light-weight draw works is completed smoothly and easily.

The full range of engine speeds, driving through the hydraulic transmission, is controlled by the accelerator, eliminating the shifting of gears. Gear transmissions are also available with all engines.

Smooth operating friction clutches, controlled by compressed air, provide a double range of drum speeds. This "Hi-Lo" drive makes it possible to instantly double the line speed without stopping the block or rotary table.

The friction clutch driven drum and rotary table allow the drill pipe to be lifted any distance within the kelly length while the table is rotating, as when milling out liners, reaming or "drilling-up" through cavey formations.

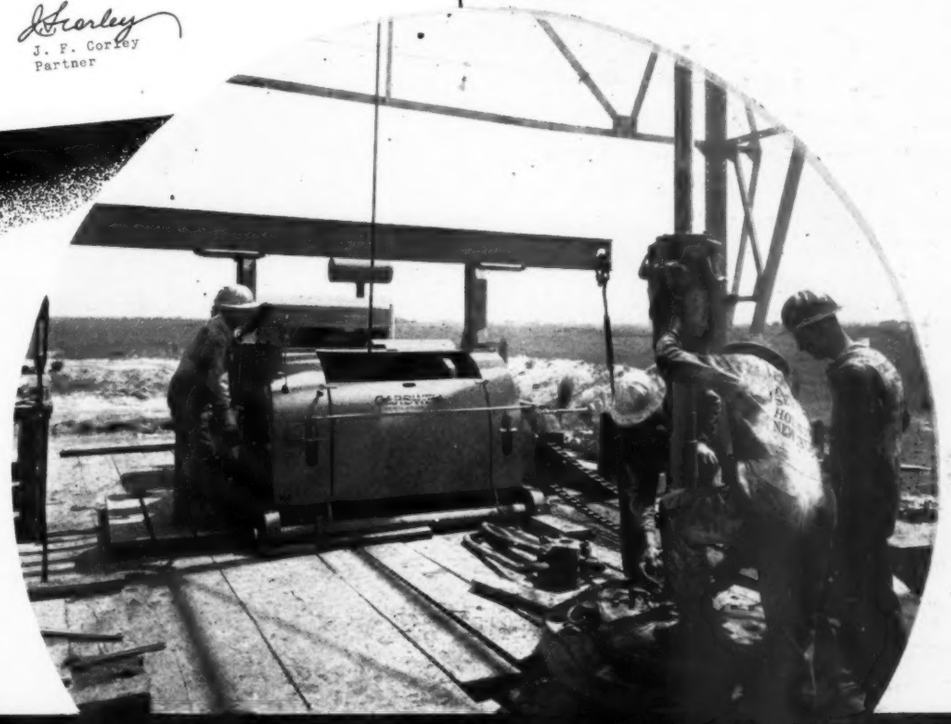
Air controls also operate the countershaft brake, automatic cathead and friction clutched rotary table drive. The rotary table drive is equipped with a brake which automatically applies when the clutch is disengaged.

The new "Cardwell" braking system provides dual safety brakes that can operate independently and hold the full capacity load should one brake fail. The brakes are quickly applied by a slight pressure on the brake lever and are easily adjusted to feed properly when drilling. The water-cooled brake flanges are demountable and made of special alloy steel, heat-treated to give three to four times the life of ordinary steel flanges.

The lightweight and one-piece design of the Model S makes it quick to rig up and easy to transport. The lightest and strongest of alloys are used in the all-steel construction of this rig. The heat-treatment of every wearing part, to the last pin and pinhole in the controls, saves thousands of dollars in down time and repair costs. The many features of this "Cardwell" rig will save more than the purchase price during the life of the rig.

Ask for prices on our slush pump assemblies powered with an engine interchangeable with the draw works engine; then a bare standby engine is most practical.

"Cardwell" rigs are sold only direct from factory to user, with the result these rigs cost less than others of like size.



● Model S is available with engines up to 225 h.p. and is recommended for rotary workover and well servicing to 10,000 feet; for rotary drilling with 3½" drill pipe to 6,000 feet and to 4,500 feet with 4½" drill pipe.

CARDWELL ALLSTEEL
REG. U.S. TRADE MARK PAT. OFF.
THIS TRADE MARK INSURES HIGHEST QUALITY AT LOWEST PRICE

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• We Build 90 Models and Sizes of Servicing Winches and Drilling Rigs — Send your well depths and details of your well equipment for recommended model and size.

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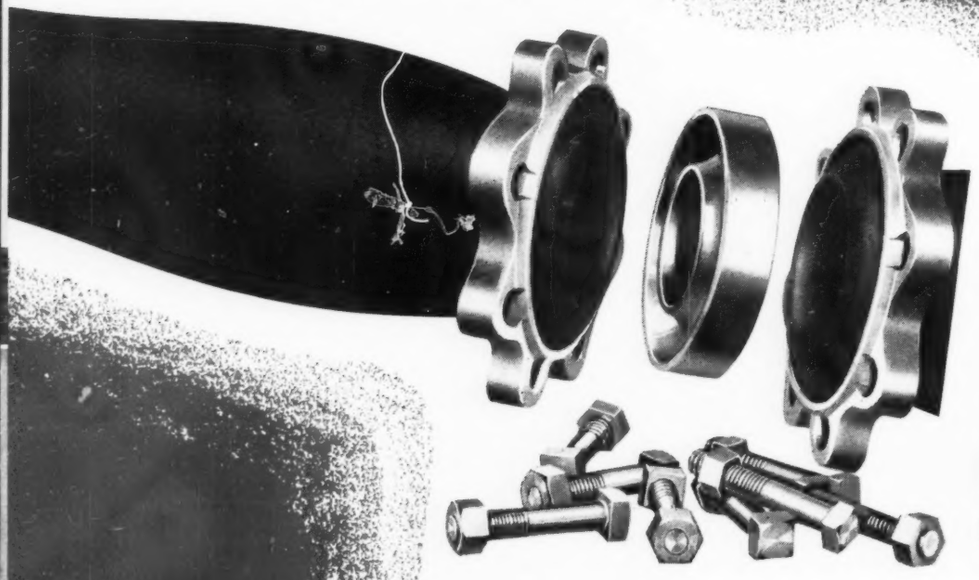
This is where you save STANDBY INVENTORY and REPLACEMENT dollars with

Hewitt MULTIPLE-LENGTH ROTARY HOSE

Smart drillers are crediting the exclusive new Multiple-Length feature of HEWITT Rotary Hose for saving standby inventory and replacement costs. Here's how it works. With the conventional 50 to 60 ft. length of hose, replacement occasioned by accidental injury or normal wear involves the entire length from standpipe to swivel. But HEWITT Multiple-Length Rotary Hose utilizes a specially developed and pressure-tested built-in coupling construction that makes it possible to divide the length. Hence replacement involves only one piece—half the usual length—at half the usual cost. Naturally, standby inventory is also cut in half!... Thus is new economy added to the many features that have made HEWITT hose the choice of drilling operators year after year. Special high tensile rubber and synthetic oil-proof compounds, extreme flexibility and generous margins of strength to withstand the highest pressures, help to [illegible] records in drilling time and savings—with drilling safety. Ask your HEWITT distributor for details.



...AND SAVE WITH *Safety*

HEWITT MULTIPLE-LENGTH Built-in Rotary Hose Coupling is

★ **TESTED** thoroughly in field and laboratory and proven able to withstand the most severe working conditions with ample safety margins.

★ **REINFORCED** with multiple layers of high tensile spring steel wire clamped and bolted with steel bands.

★ **RUBBER COVERED** all the way through the coupling shank and over the face, preventing any exposure of metal to wear.

★ **FULL DIAMETER** same as the rest of the hose, providing full water way with no flow-retarding obstructions.

HEWITT
RUBBER CORPORATION • BUFFALO, N. Y.

HEWITT Distributors are listed in Classified Telephone Directories under "Rubber Goods" or "Belting"

HOSE • CONVEYOR AND TRANSMISSION BELTS • PACKING

How thorough lubrication lengthens the service life of wire rope

This is No. 5 in a series of informative articles for Wire Rope users prepared by the Macwhyte Wire Rope Company.

The importance of thorough Wire Rope lubrication in obtaining safe and economical service cannot be overestimated.

Wire Rope is a complicated piece of machinery. A 6 x 19 rope, for instance, is made up of 114 wires plus a core (which may be hemp, or an independent wire rope center).

As the rope bends over sheaves and drums the wires continually move and rub against each other. Each wire becomes a bearing surface that grinds and wears against other wires—unless all are properly lubricated.

Proper lubrication is just as important to wires in your rope as it is to gears in your car.

Two Lubricating Methods

1. Internal Lubrication. A most effective internal lubrication has been pioneered by Macwhyte. During the rope's manufacture each wire is thoroughly covered, spaces between wires completely filled, with a special lubricant. This compound does not dry or flake off in extreme cold. It does not melt or run under summer heat.* This special lubricant protects against internal friction and corrosion.

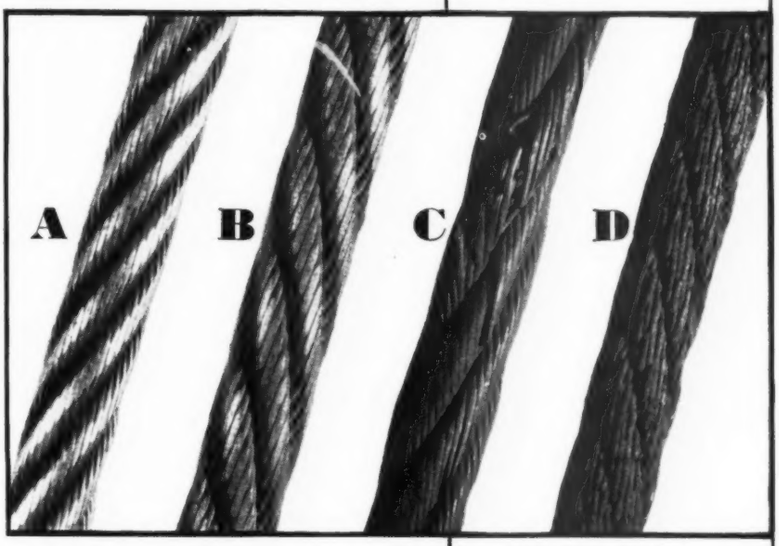
2. External lubrication, applied on the job, acts to seal in the internal lubrication. It also guards external wires against corrosion and reduces abrasion.

CONCLUSION: If a wire rope user wants the greatest possible service from wire rope, it is wise to buy a rope which is internally lubricated during manufacture (not all ropes are). No external applications applied later can possibly reach the inside wires where it is needed most.

Engineering Service

Use Macwhyte Engineering Service—a wire rope or lubrication recommendation may save you many dollars. It's a part of our friendly service to help you get the most from your wire rope dollar.

*For complete information ask for interesting folder, "The WHY IN MACWHYTE Internal Lubrication."



MACWHYTE COMPANY
2940 Fourteenth Avenue, Kenosha, Wisconsin
Manufacturers of Rope Wire—Braided Wire Rope Slings—Monel Metal Wire Rope—Stainless Steel Wire Rope—Cable, Tie-Rods, and "Safe-Lock" Terminals for Aircraft; Wire Ropes for all industrial requirements.

NO. 480

FROM THE FIELD

A This rope contains Macwhyte's Special Internal Lubrication. External lubrication was applied periodically during service. *Result:* Uniform wear, maximum service.

B This rope was internally and externally lubricated with Macwhyte's Special Lubricant during fabrication. It was never externally lubricated in service, however. *Result:* efficient service, but had to be removed prematurely because exposed outer wire became rusty. When removed from job inner wires were still in good condition and well lubricated—indicating that external application of a good lubricant would have prolonged rope life.

C No internal or external lubrication was applied to rope "C." Strands and wires became frozen, which eliminated freedom of wire and strand movement when the rope flexed over sheaves. *Result:* Premature rope failure before wires had received normal wear.

D An idle rope should always be kept lubricated. Rope "D" was removed from service and stored for future use. Not being protected, however, rust and corrosion set in and ruined the rope. *Result:* unnecessary waste and high rope cost that lubrication could have prevented.

MACWHYTE
Whyte Strand
PREformed WIRE ROPE
The Wire Rope with THE Internal Lubrication

NEW YORK · PITTSBURGH · CHICAGO · FT. WORTH · PORTLAND · SEATTLE · SAN FRANCISCO
Distributors throughout the U. S. A.

The Petroleum Engineer, published monthly August through June, semi-monthly in July, by The Petroleum Engineer Publishing Company, seventh floor Allen Building, Dallas, Texas. Subscription price, $2.00 per year, $3.00 for 2 years, 25 cents a copy. Entered as second-class mail matter May 1, 1932, at the post office at Dallas, Texas, under the act of March 3, 1879.

How old will your well head installation be three years from now?

By definition, well control must insure for the operator complete protection against the unseen forces of nature from the time the well is spudded in until those would-be forces of destruction are spent through flowing production.

Yesterday's practices must be forgotten. Then, wells were brought in wide open and, due to pressure dissipation, were "on the beam" in about 30 days. Well control was of no concern after the well was on the pump—its job was done.

But today it's different. Today the operator must select his control equipment to take care of the anticipated long flow-life of the well. *If the choice is unwise, the cost of error is dear.*

Gray Systems of Well Control fill the needs of today *and* anticipate the needs of tomorrow.

GRAY

TOOL COMPANY

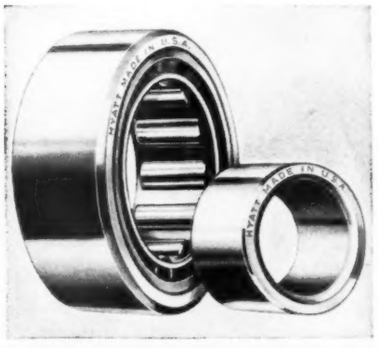
HOUSTON

***West Coast Distributor:* WAGNER-MOREHOUSE, INC., Los Angeles**

RIGHT from the ground up!

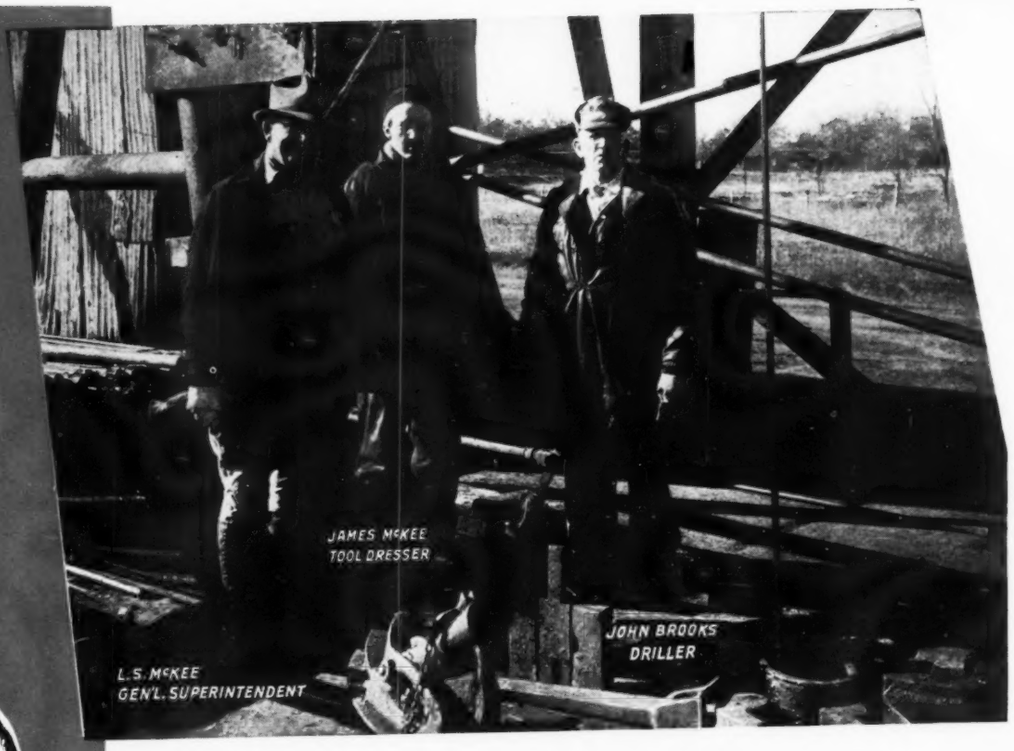
AMERICAN PUMPING UNITS

built by American Manufacturing Company of Texas are Hyatt equipped. Another indication of the preference for Hyatts in oil fields where the going is tough.



Pumping units, drawworks, rotaries, blocks, pumps, etc., equipped with Hyatt Roller Bearings, are giving many extra years of profitable life. Wherever work is to be done...wherever shafts, gears and wheels turn, machines have a habit of staying *right* with Hyatts. That's why so many builders of oil field equipment use these better bearings. Where can we serve you? Hyatt Bearings Division, General Motors Sales Corporation, Harrison, N. J., Chicago, Detroit, Pittsburgh and San Francisco.

HYATT *Roller* BEARINGS



BEN FRANKLIN NEVER HEARD OF CABLE TOOLS

...But he knew his Economics!

"A penny saved is a penny earned," said Ben, and he always looked for a place to save it. There are *many* places where the cable system of drilling gives *you* a definite opportunity to *save* money.

No operator can afford to be passive where Economy is concerned. There are other considerations, of course, but in the end it's the figures on the profit-and-loss columns that count.

If Economy is important to you, consider cable-tools in your drilling program. And remember to specify SPANG CABLE TOOLS.

SPANG & COMPANY · Butler, Pa.

SPANG

THE YARDSTICK OF CABLE-TOOL VALUE

Spang & Company occupy a position of undisputed leadership in the cable-tool industry. Today, Spang Cable Tools are the yardstick by which the value of cable tools are measured. Next time, Specify SPANG!

SPANG

THE BIGGEST CABLE (The Higher Standard) **NAME IN TOOLS**

..We Urge
TOTAL DEFENSE NOW

FORTIFY YOUR STOCK TANKS AGAINST BAD OIL THIS FALL AND WINTER BY INSTALLING BS&B HEATING AND TREATING EQUIPMENT NOW

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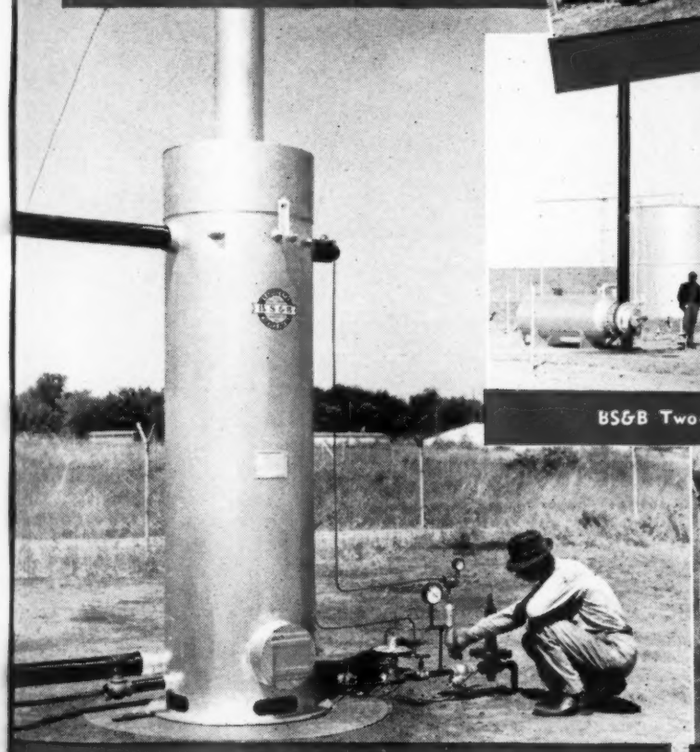
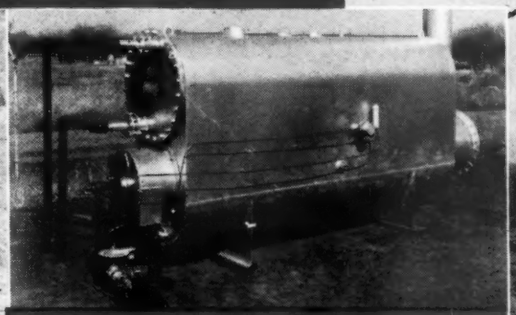
BS&B Horizontal Fire Tube Heater

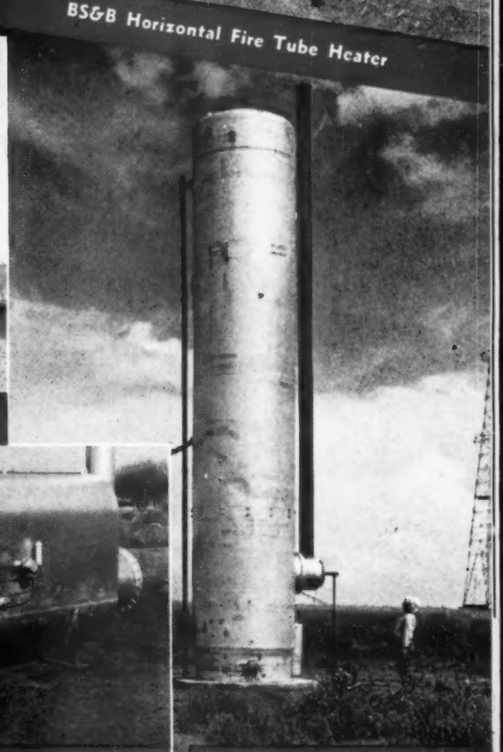
BS&B Two-Unit Treating System



BS&B Vertical Heater



BS&B Indirect Heater



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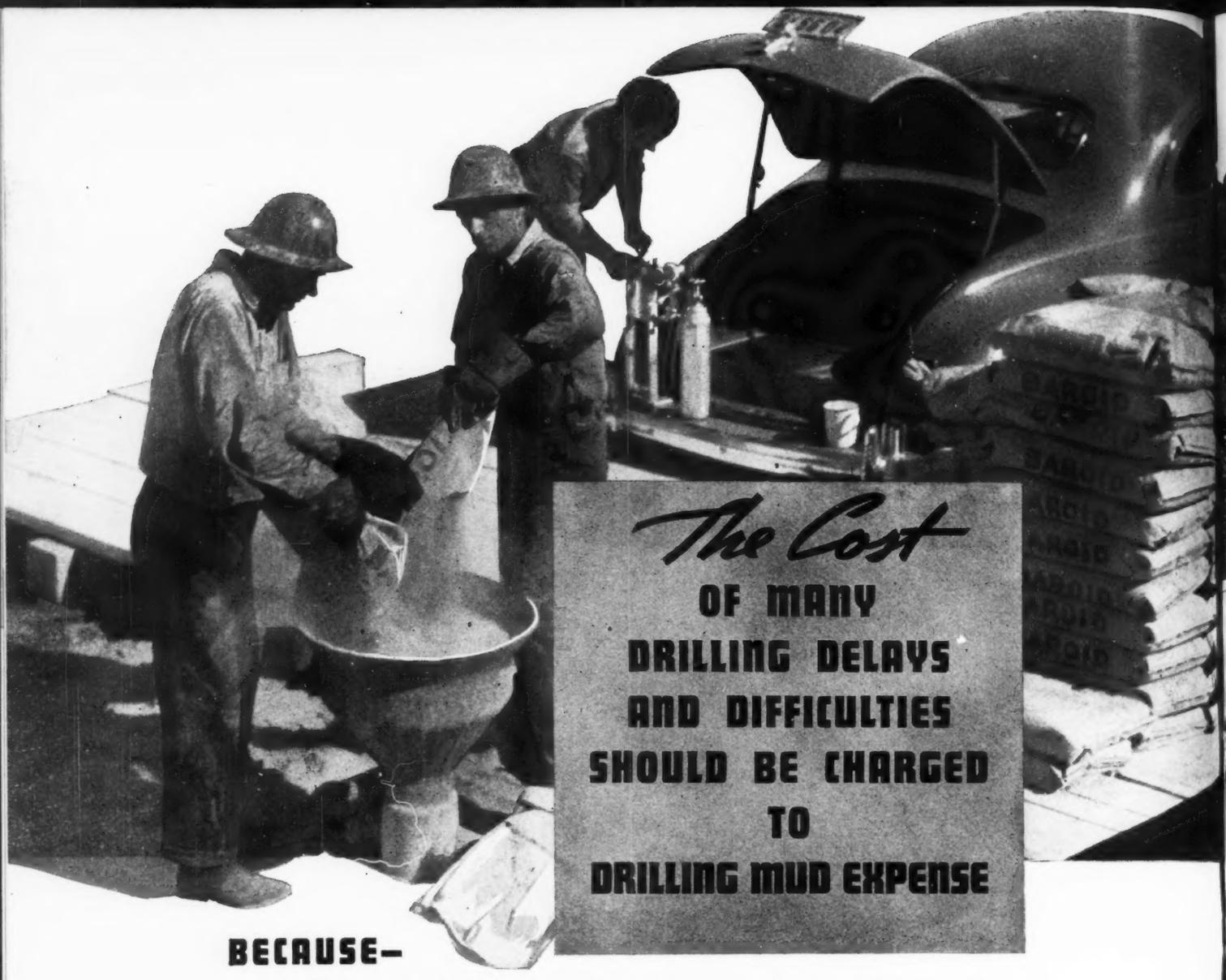

The Cost OF MANY DRILLING DELAYS AND DIFFICULTIES SHOULD BE CHARGED TO DRILLING MUD EXPENSE

BECAUSE—

Stuck pipe, which is one of the most commonly encountered troubles, is usually caused by improper mud. The reasons for stuck pipe are usually caving of the hole, settling of cuttings, or a thick mud cake. Mud which is properly selected for the specific drilling conditions can eliminate these drilling troubles.

One expensive fishing job (which might be eliminated by suitable mud) may be much more costly than the slightly higher cost of using the proper mud on a great number of wells with complete safety. Muds of slightly increased weight and suitable colloidal content provide protection against these troubles at minimum cost.

The best way to insure your wells against troubles is to use Baroid Products and Service.

Baroid Service Engineer Weighing Mud with Hydrometer

BAROID PRODUCTS

BAROID and COLOX–Extra Heavy Drilling Muds. • AQUAGEL–Trouble-Proof Colloidal Drilling Mud. • STABILITE–An Improved Chemical Mud Thinner. • BAROCO–An Economical, Salt Water-Resisting Drilling Clay. • FIBROTEX–For Preventing or Regaining Lost Circulation. • AQUAGEL for CEMENT–For Setting Casing and Restoring Lost Circulation. • SMENTOX–For Reconditioning Cement-Cut Muds. • ZEOGEL–Special Clay to be Used as a Suspending Agent When Salt or Salt Water is Encountered. • TESTING EQUIPMENT–For Drilling Mud Analysis and Control. BAROID WELL-LOGGING SERVICE—Formation Information Through Mud Analysis.

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Baroid Products and Servi... Engineers are available in ... active oil fields of the U.S.

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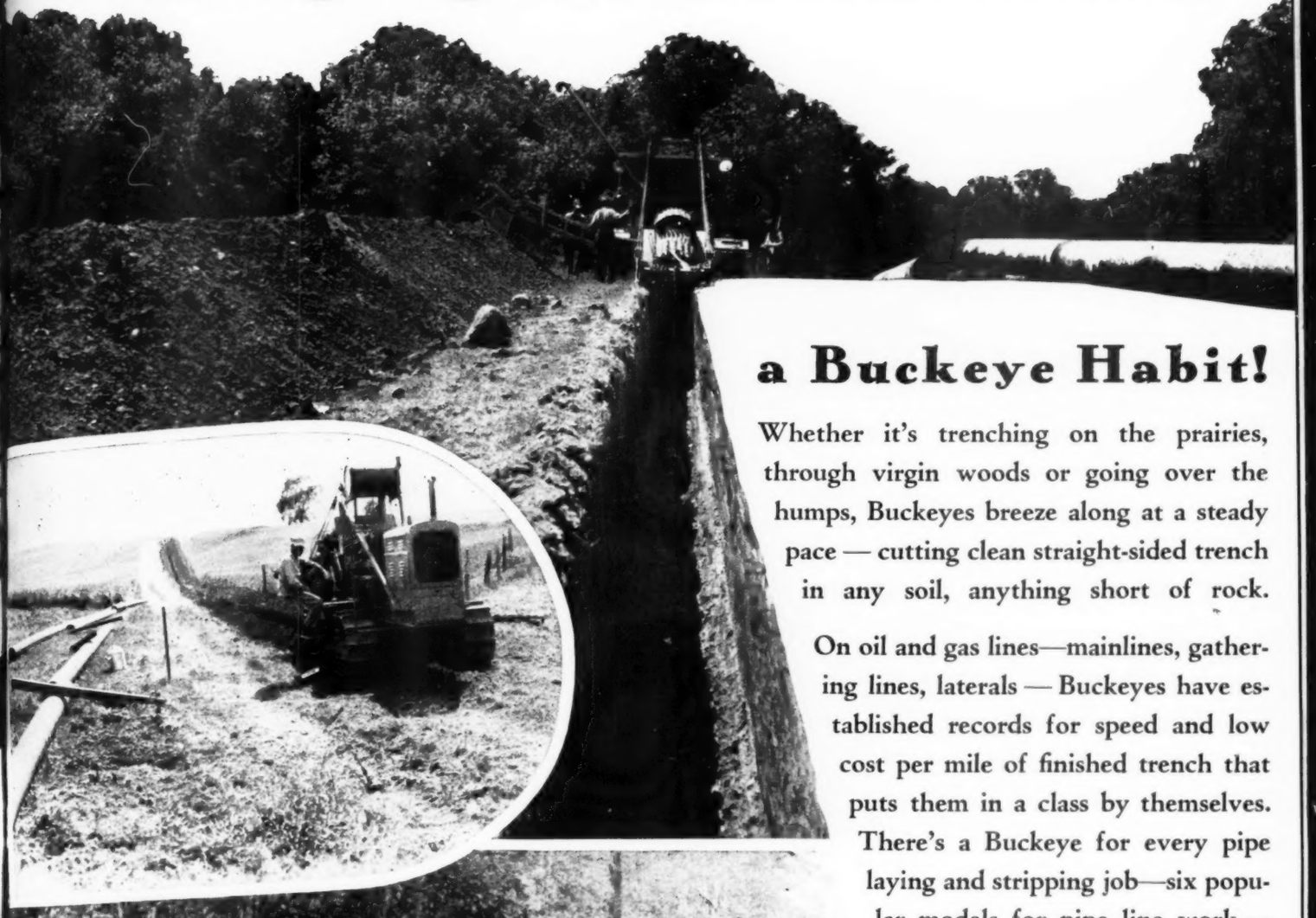
Making Pipe Line Trench Faster



a Buckeye Habit!

Whether it's trenching on the prairies, through virgin woods or going over the humps, Buckeyes breeze along at a steady pace — cutting clean straight-sided trench in any soil, anything short of rock.

On oil and gas lines—mainlines, gathering lines, laterals — Buckeyes have established records for speed and low cost per mile of finished trench that puts them in a class by themselves. There's a Buckeye for every pipe laying and stripping job—six popular models for pipe line work — dozens of models in the entire line for every trench excavating purpose; wheel and boom types.

Send today for your copy of detailed Pipe Line Trencher Bulletin now on the press!

Buckeye Clippers feature vacuum power control — speed slush pit digging, pipe laying, building erection, yard work. Quickly convertible from crane to ½, ⅝ or ¾ yard shovel.

Buckeye

THE BUCKEYE TRACTION DITCHER CO. FINDLAY, OHIO

Makers of Trenching Machines, Convertible Shovels, Fine Graders, Surface Graders, Spreaders and Tractor Equipment

Distributors in All Principal Cities

Check Buckeye First!

Perfectly Balanced

MIRACLE ROCK . . .
WORLD'S LARGEST
BALANCED ROCK,
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DRILL COLLARS

UNIFORM PHYSICAL PROPERTIES

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ACCURATE ALIGNMENT

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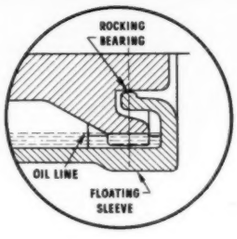
MAXIMUM HARDNESS AND TOUGHNESS

REED ROLLER BIT COMPANY

P. O. BOX 2119, HOUSTON, TEXAS

FAST'S COUPLINGS

Self aligning



This illustration shows Fast's construction. The load-carrying surfaces are protected from wear by a positive film of oil. This oil is kept permanently clean by the rocking bearings which make precise metal-to-metal contact and are in the one position where they form permanent dust and moisture-proof seals. There are no perishable parts, grids, laminated plates or laminated pins. The only attention required is an occasional oiling.

Engineers who check costs and results know that experiments with untried couplings are too costly to risk. Fast's Couplings have been proven "on the job" for many years. To eliminate gambles and avoid operating troubles—specify *genuine* Fast's Couplings on the machinery you purchase.

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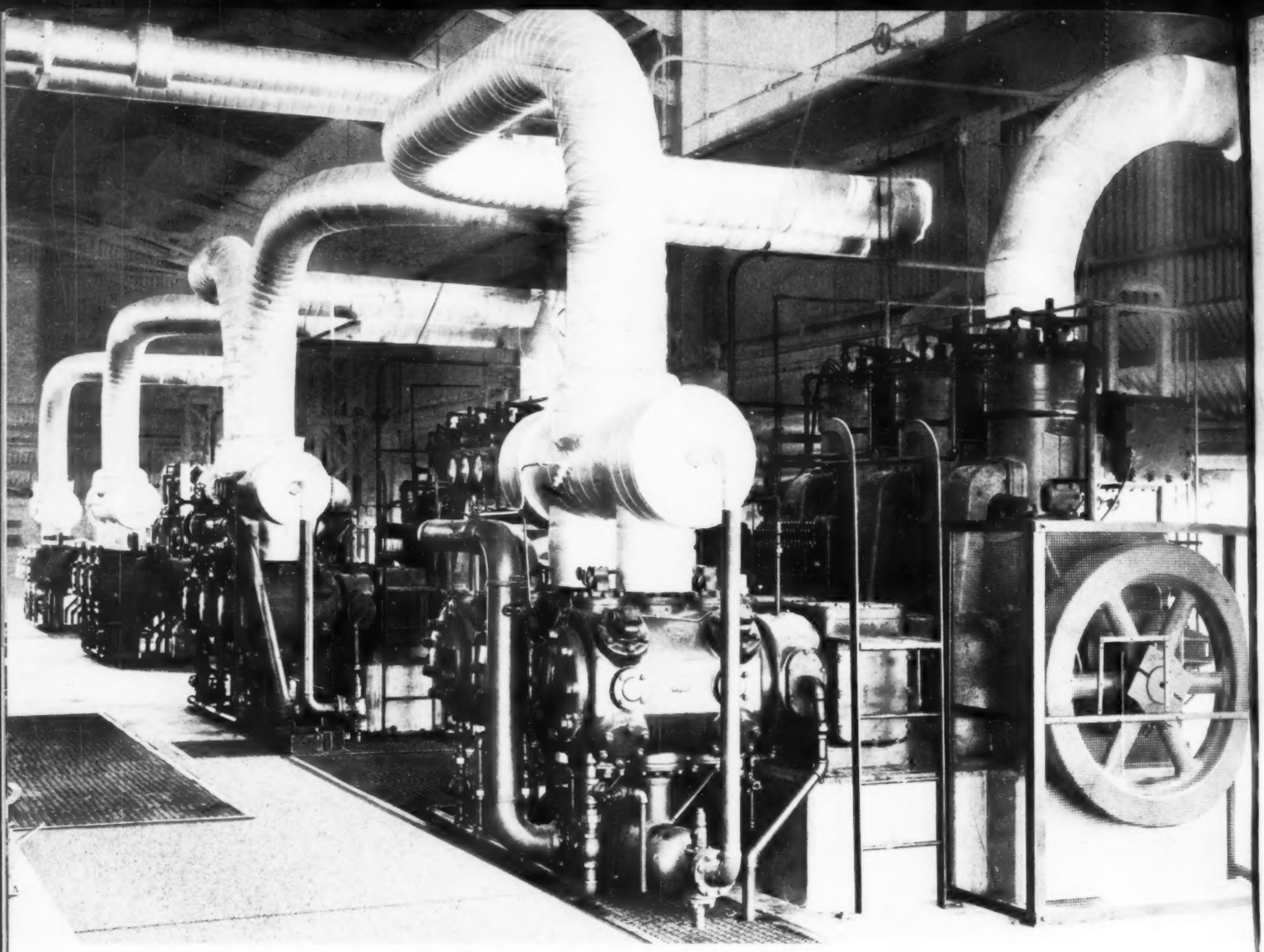

Design and Operating Engineers can obtain a copy of our Piston Ring Handbook by writing . . . on company letterhead.

FOR TOP-NOTCH PERFORMANCE IN DIFFICULT SERVICE

Clark Compressors are used in Oil Fields throughout the world, where service conditions are frequently exceptionally severe, and where limited repair facilities make long life and dependability of the utmost importance. It is thus essential to maintain the highest standards of materials and workmanship, as well as of design. Clark Brothers, makers of Clark Compressors, have been users of American Hammered Piston Rings for 15 years.

If you have some responsible application where service is severe and top-notch performance is essential, take a tip from compressor manufacturers and the hundreds of oil field users, and let American Hammered Piston Rings do the job right for you.

KOPPERS COMPANY · AMERICAN HAMMERED PISTON RING DIVISION · BALTIMORE, MD.

OTHER KOPPERS PRODUCTS: Coal . . . Coke . . . Fast's Couplings . . . Treated Timber, Poles, and Piling . . . Waterproofing . . . Built-up Roofs . . . Materials Handling Systems . . . Special Machinery

American Hammered Piston Rings

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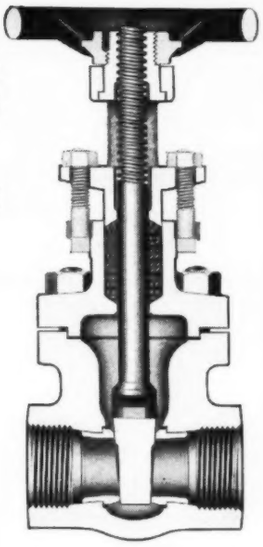
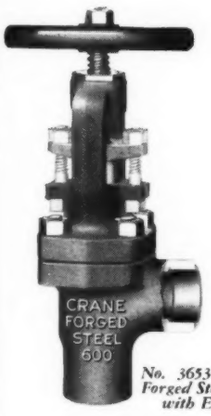
"SO THAT'S WHY THEY CALL THEM *tailor-made* SMALL STEEL VALVES"

Cross-section view of 600-pound No. 3607-X Radio-cast Steel wedge gate valve with Exelloy disc, seats, and stem for oil and oil vapor handling.

•

Crane Small Steel Valves are made with screwed, flanged, and socket weld ends.





No. 3653-X 600-pound Forged Steel angle valve with Exelloy trim.

No. 3692-XS 600-pound Radio-cast Steel vertical ball check valve with Exelloy to Steel trim.

No. 3656-X 600-pound Forged Steel globe valve with Exelloy trim.

They're Designed to Fit Oil Country Service Needs

FIRST of all, Crane Small Steel Valves are made specifically—"tailor-made"—for the working conditions of high pressure service. They embody the most ideal construction features desired in valves for pressure-temperature lines.

Each type is built of materials aiding finest development of design for better flow control. Gate valves and vertical checks are of Crane Radio-cast Steel—the most scientific steel casting process. Globe and horizontal check valves are made by Crane improved forging methods.

They are of heavier section where service—or installation stresses—require greater strength. They are lighter in places where weight in ordinary valves is merely excess weight.

Because of Crane "tailor-making," these valves look different and are different. They look and are well proportioned, more modern. They look and are better adapted in a score of ways to the actual service requirements to which you subject them.

Despite "tailor-made" adaptability to your service needs, Crane Small Steel Valves exact no premium. That's because they're made by the most efficient manufacturing techniques. What's more, they're made in a full line of gates, globes, angles and checks—in 8 sizes up to 2 inches.

But, you'll never know the goodness and superiority of Crane Small Steel Valves until you've judged them for yourself. The quickest way to do that is to call your Crane Representative right now! Or, you can send the coupon below for a new catalog which illustrates and describes the line.

CRANE

1940 OUR 85th YEAR

CRANE CO., GENERAL OFFICES:
836 S. MICHIGAN AVE., CHICAGO
VALVES • FITTINGS • PIPE
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Without obligation, please send me a catalog on the new line of Crane Small Steel Valves. PE-9-40

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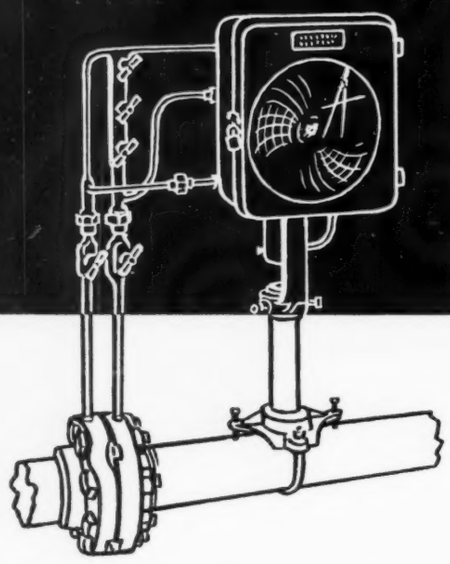
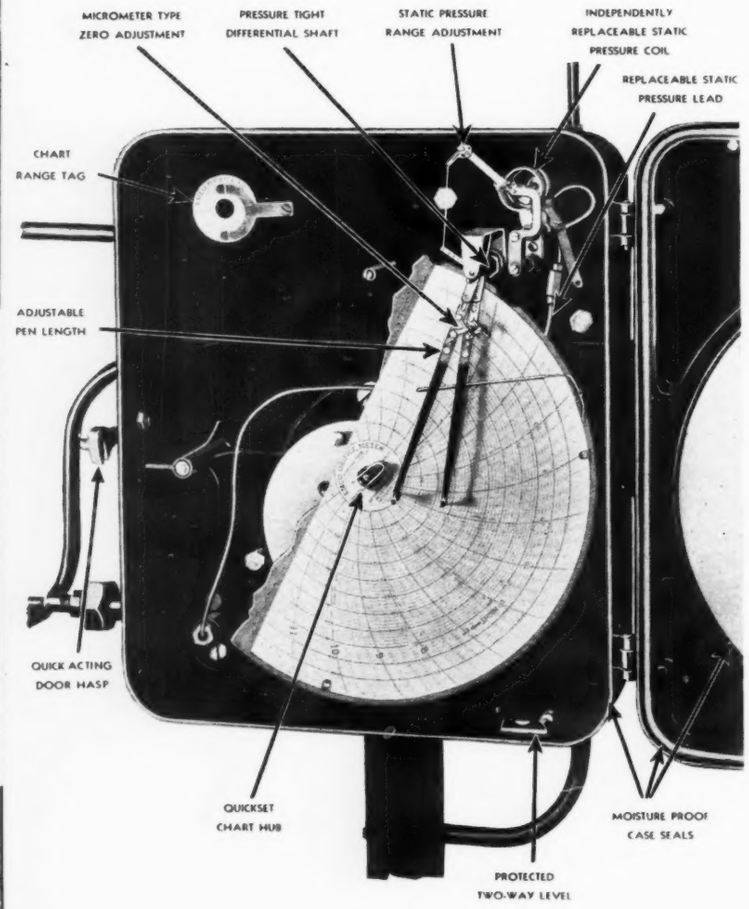
Details Make Perfection

. . . IN THE EMCO TYPE 38 ORIFICE METER





PERFECTION is only an ensemble of detail. In the EMCO Type 38 Orifice Meter the care and attention which have been devoted to even the most minute detail is best evidenced in the design and construction of this superior meter.

The case and case parts are outstanding examples of design perfection. The case is sufficiently large so that charts can be changed with ease. All case parts are readily accessible.

The case and cover are aluminum die cast. They are sealed by a moisture-proof sponge rubber door gasket. A quick acting door hasp seals compression as well as permitting opening or closing with one easy motion. A door lock is incorporated in the hasp. Of interest, too, is the location of the two-way level inside the case where it is protected from damage. This level is lined up initially with the differential chamber.

The chart range tag indicates at a glance the proper chart to install at each location. A "quick set" chart retainer which is integral with the chart hub, eliminates the annoyance of the loose type of retainer suspended from a chain. The pen lifter, integral with the chart plate, lifts both pens free without excessive jarring.

The service man will appreciate the improved pen construction which provides a micrometer zero adjustment and a readily accessible adjustment for pen length. However, a fixed setting for the pen is also provided which permits removal for cleaning and exact positioning upon replacement.

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